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FORTY-FOURTH
PROGRESS REPORT
OF
THE FIRESTONE TIRE & RUBBER COMPANY
ON
BATTALION ANTI-TANK PROJECT
UNDER

Contract Nos. DA-33-019-ORD-33

DA - 33 - 019 - ORD - 1202

ORDNANCE DEPARTMENT PROJECTS

TS4-4020—WEAPONS AND ACCESSORIES

TM1-1540—AMMUNITION

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COPY NO. 54

THE FIRESTONE TIRE & RUBBER COMPANY
Defense Research Division
Akron, Ohio

MARCH 1954

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Armed Services Technical
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Akron, Ohio
May 25, 1954

Subject: Corrections To Be Made In Forty-Fourth Progress
Report (March) of Firestone Defense Research
Division on Contracts DA-33-019-ORD-33 and
DA-33-019-ORD-1202.

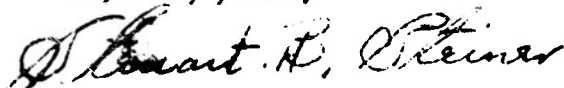
In the subject report which you have just received there are
two errors which have been called to our attention and which we request
that you correct in your copy or copies.

- (1) Figs. 17 and 19 on pages 25 and 26 are transposed. The
captions are correct as they appear but the plots and data
immediately below are transposed. Beside the plot of
Fig. 17 will you write "this should be Fig. 19" and beside
the plot of Fig. 19 will you please write "this should be
Fig. 17".
- (2) A typographical error appears in Table XIV on page 44.
In the right hand portion of the Table under Rotational
Behavior the two rows of data are transposed in the last
five columns. That is, under the headings 15, 30, 45, 60
and 90 rps columns the larger number should be in the
top row, e.g. 19.06 ± 3.21 should exchange positions with
 18.34 ± 1.45 and this same change in order (bottom number
moves up to top row and top number moves to bottom row)
should be made in the remaining four columns.

It will avoid considerable confusion if you will indicate these
changes in your copy (or copies) and indicate that such changes have been
made by signing one copy of this form and return to our attention. Place
the other copy within the report to verify your changes.

Thank you for your assistance.

Very truly yours,



Stewart B. Steiner

The above changes have been noted and corrected in the copies of
this report for which I am responsible.

Signed _____

SBS:mjm

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5447-35663

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**FORTY-FOURTH
PROGRESS REPORT
OF
THE FIRESTONE TIRE & RUBBER CO.
ON
BATTALION ANTI-TANK PROJECT**

**Contract Nos.
DA-33-019-ORD-33 (Negotiated)
DA-33-019-ORD-1202**

**RAD Nos. ORDTs 1-12383
ORDTs 3-3955
ORDTs 3-3957
ORDTA 3-3952**

**THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
Akron, Ohio
MARCH, 1954**

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ABSTRACT

Weapon System - The requirements for a firing control system for the multi-gun ONTOS weapon system are presented. A simplified, single package electrical control system developed by Firestone is illustrated and the features are discussed.

T119 Projectile - Ten projectiles with double "O" ring obturators were fired from a smooth bore tube to determine the effect of obturation alone upon the accuracy of the projectile. The test results are given.

Nineteen projectiles with grooved nose caps (previously tested for impact sensitivity) were fired to evaluate the effect of the nose cap design on projectile accuracy. The test results indicate that the nose cap design does not have any detrimental effect upon the accuracy of the projectile.

Seventy rounds were fired to study the fin opening mechanism. A new piston stop design is illustrated. The series of tests were fired to establish the proper amount of interference between the stop and the housing. The dimension limits on piston and housing diameters that will permit consistent functioning of the tail assembly under the most extreme conditions are determined from these tests.

T171 Projectile - Four accuracy programs were fired at Erie Ordnance Depot involving T171E10 and T171E11 projectiles at ranges of 1000 and 1500 yards. The test data are presented and discussed.

T120 Projectile - Dynamic tests for determining the performance of projectiles with spin compensating cones are discussed. Preliminary firings with a projectile of the folding fin type were made to evaluate spin rate. Further tests are planned.

Six test bodies (for double body projectile studies) were fired with various wall thicknesses to determine the minimum wall thickness allowable in order to reduce weight. The test results are analyzed.

Penetration Studies - A study of the effect of cone angle and flash tube diameter upon the standoff and rotational penetration behavior of 3-inch copper cones has been completed. The test data are given and the results discussed.

Two series of tests were conducted under contract DAI-33-019-501-ORD (P)-16 but are summarized here because of the importance of the data to this contract: (a) comparison tests with "drawn" and "shear formed" P83580 Al cones, and (b) performance tests with double angle tapered wall copper cones.

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THE WEAPON SYSTEM

ONTOS Firing System

Preliminary tests of the multi-gun ONTOS weapon by the using services emphasized the need for:

1. An indicator system to serve as a memory for the gunner. This indicator preferably should tell the gunner when a rifle is loaded and when empty.
2. A simpler and more reliable firing mechanism.
3. Better protection for personnel when loading and closing the rifle breeches.
4. Complete interchangeability between BAT and ONTOS rifles. In an effort to meet these requirements, several different systems have been manufactured and tested but have enjoyed only limited success.

The systems tested have employed:

1. A breech operating mechanism controlled from the inside of the vehicle.
2. An auxiliary firing system.
3. An auxiliary attachment which indicates when the rifles are fired.

It is understood that the breech operating mechanism is required for safety of personnel only. For example, in the T170 rifle the breech is closed on the loaded shell with a cocked firing pin and a malfunction can fire the shell as the breech reaches the locked position. This condition is particularly hazardous when working with a multi-gun system and has so far been overcome by the use of a breech operating mechanism which allows the personnel to remain under cover when the breeches are closed. All of the firing systems have provided a mechanism which

operates through the cable system furnished with the rifle. In order to accomplish the desired result the mechanism becomes complicated. The most successful indicator system tested so far required a hole through the rifle barrel and auxiliary attachments both at that point and inside the vehicle.

In order to simplify and improve on the systems now being considered, Firestone has developed and tested a simple, single package electrical unit which meets all of the requirements listed in paragraph one. This unit (Figs. 1, 2 and 3) replaced three (3) items on the standard T170E1 rifle.

- a. the firing pin
- b. the firing pin cap
- c. the firing pin spring

The changeover can be accomplished in less than one (1) minute and is fully reversible. Thus, the rifles may be changed back and forth and fired either with the electrical unit or with the standard percussion-unit.

The operation of the new unit is as follows:

- a. Firing

A firing pin without a sear lobe replaces the standard firing pin. When the breech is opened and closed this firing pin rides the cocking cam up and down. Until the breech is safely closed the cocking cam provides a barrier which prevents accidental firing. Thus, with this unit the breeches are closed with an uncocked firing pin. Under these conditions it is believed that the breeches can be closed manually with safety, thus eliminating the need for the expensive mechanism now used to operate the breeches from

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inside the vehicle. In firing the rifles the firing pin is driven forward by a solenoid.

b. Indicator system

The indicator system operates off a cam attached to the rear end of the firing pin. A small on-off switch is actuated by this cam. Thus, if the breech is closed on an empty rifle (Fig. 4) the firing pin is pushed all the way forward and the cam operates the switch lighting a light in the

control panel. If the breech is closed on a loaded gun (Fig. 5) the firing pin comes to rest on the primer and the cam again operates the switch and turns off the light on the control panel. When the rifle fires (Fig. 6) the primer is driven rearward by the chamber pressure. This force is sufficient to carry the firing pin rearward and again the cam operates the switch and lights the light in the vehicle. Fig. 7 is the wiring diagram and Fig. 8 shows the control panel in the vehicle.

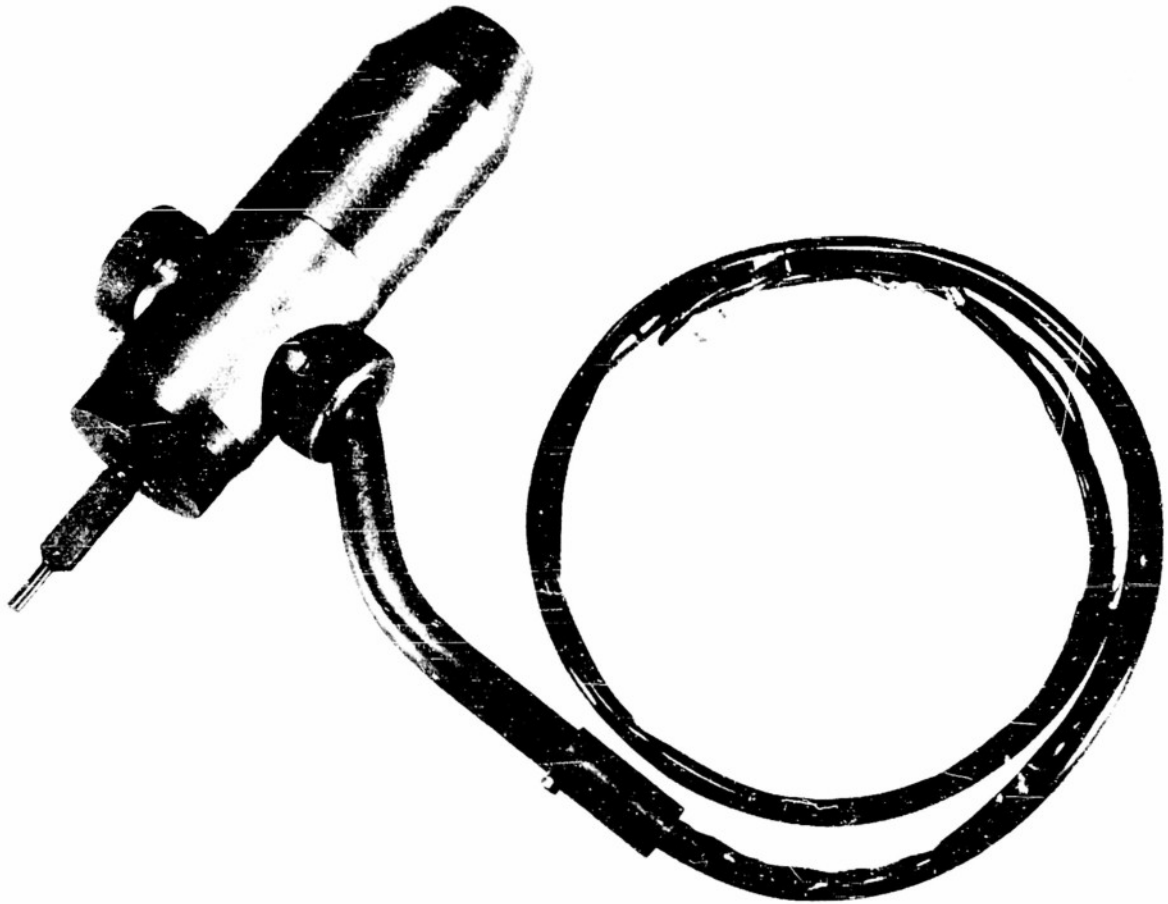


Fig. 1. Solenoid Firing Assembly.

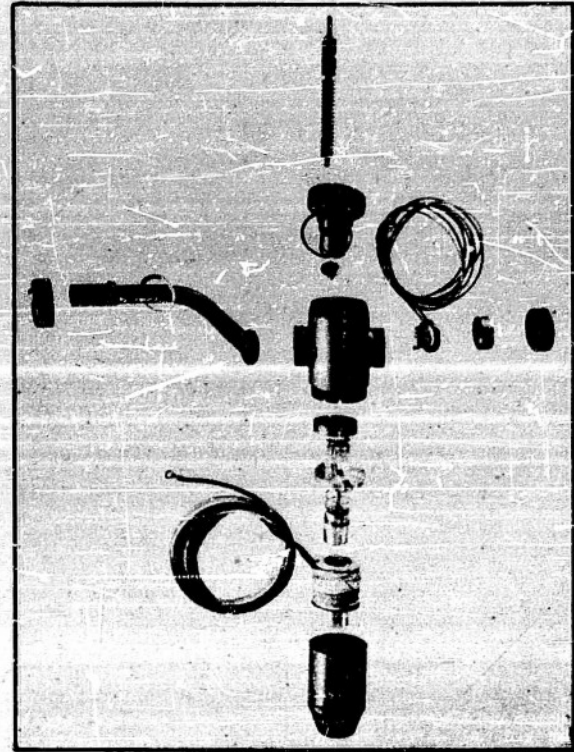


Fig. 2. Solenoid Firing Assembly.
Shown In T170 Breech Mechanism.

Fig. 3. Exploded View of Solenoid Firing Assembly.

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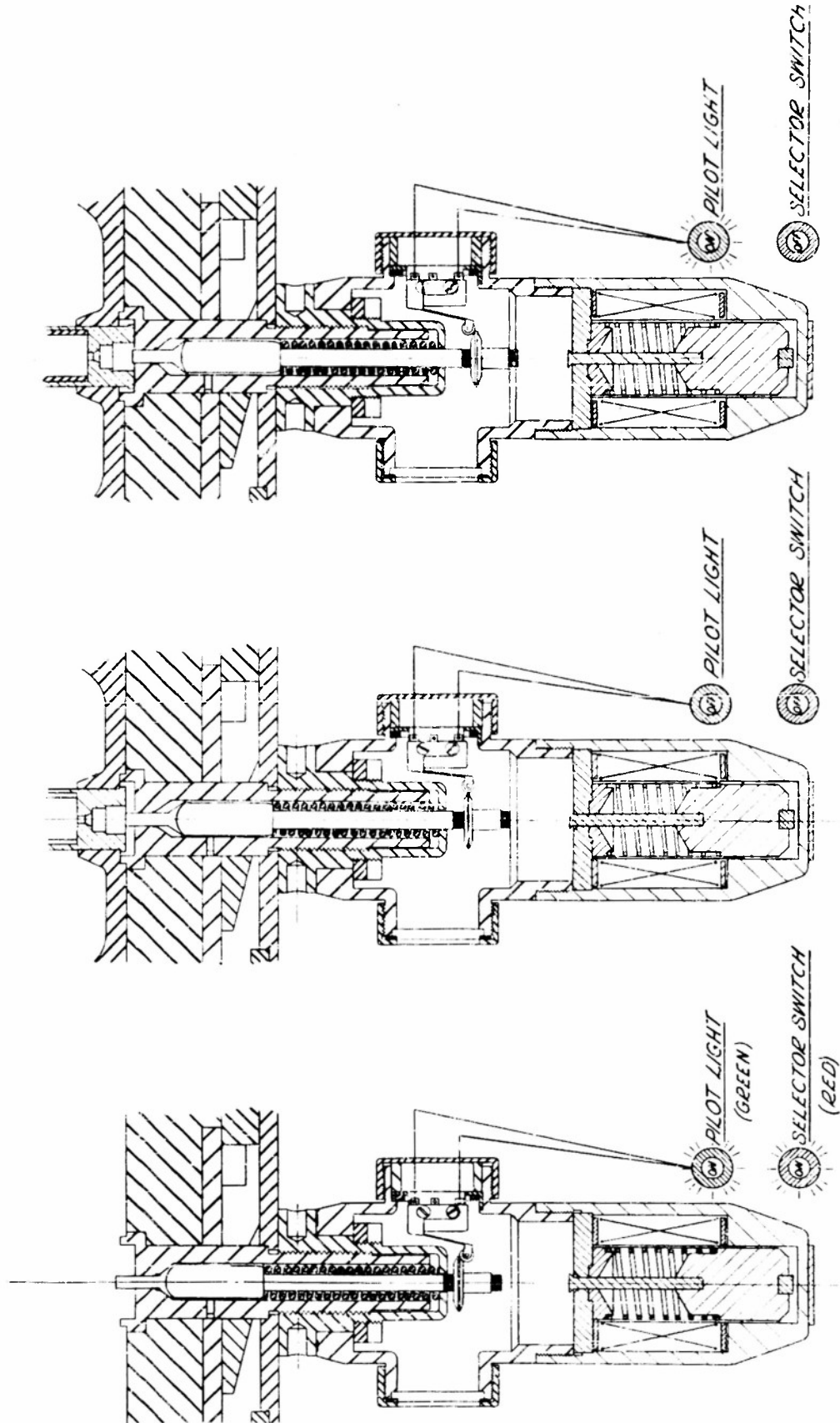


Fig. 4. Solenoid Firing System.
Rifle Empty.

Fig. 5. Solenoid Firing System.
Rifle Loaded and Selected to Fire.

Fig. 6. Solenoid Firing System.
Rifle Fired.

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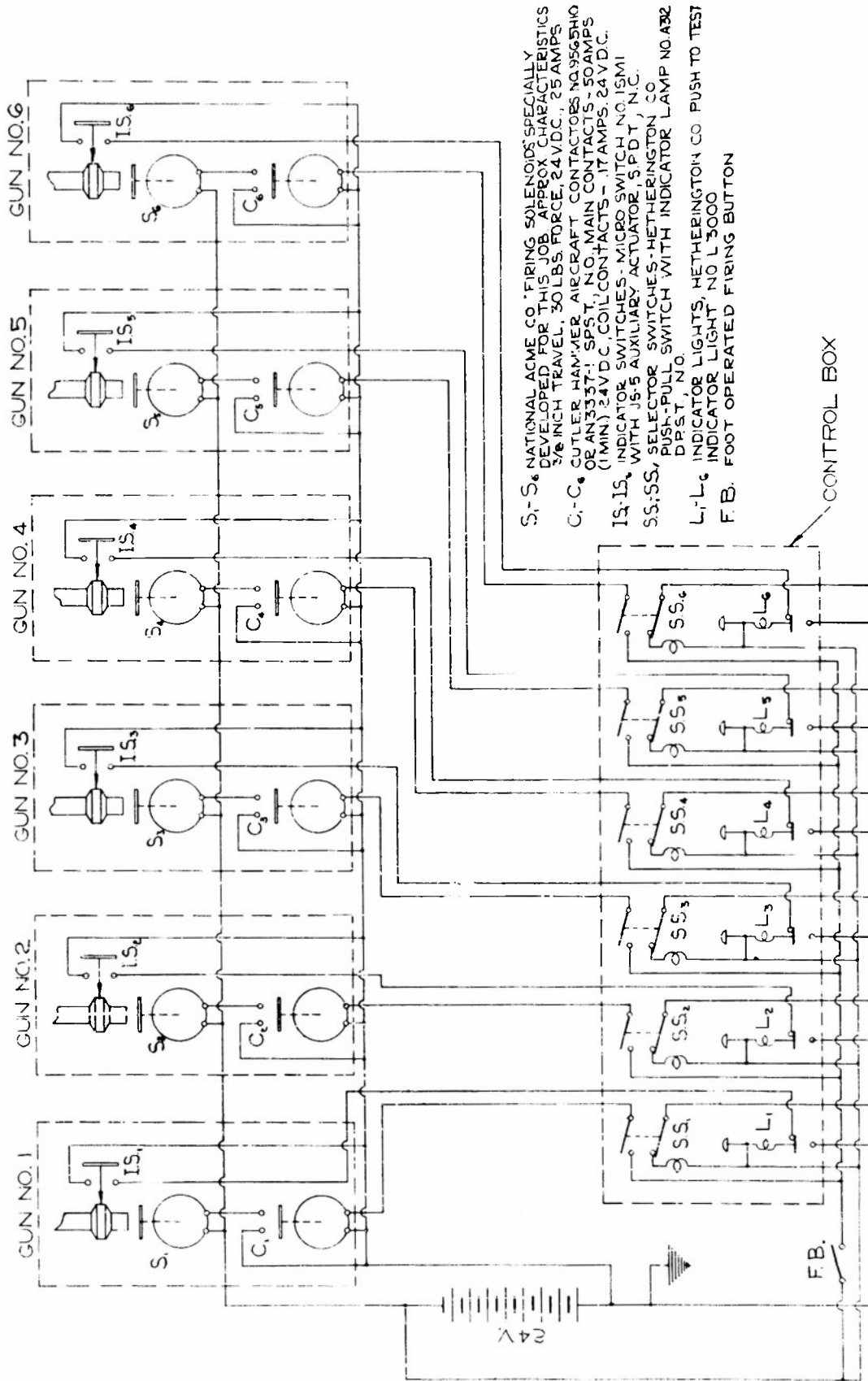


Fig. 7. Wiring Diagram.
ONTOS Firing System.

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Future Program

1. Continue test firing of ONTOS firing system for reliability of solenoid firing unit and projectile indicator unit.

2. Investigate the effect of obturation of proof slugs (with annealed copper obturating bands and rubber "O" rings) on the interior ballistics of the 90mm Test Rifle.

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T119 PROJECTILE

Projectiles With Double "O" Ring Obturators

Projectiles with two "O" ring obturators have been fired for spin measurements from a tube rifled 1/20 (see Forty-First Progress Report) and it has been suggested that the higher muzzle spin which results from the double obturator should improve the accuracy of the T119E11 projectile. It is also likely that the double ring will improve the obturation and this alone might improve the accuracy also. The effect of the increased obturation upon accuracy has been determined, independently of the increased spin, by firing ten projectiles of this type from a gun with a smooth bore tube.

Ten T119E11X projectiles, each with two "O" ring obturators and having short fins (6.92 in. long) were fired from a

smooth bore tube fixed in a rigid mount, at an 18 ft by 18 ft target at 1000 yards. The range data are presented in Table I. All ten projectiles struck the target with probable errors of dispersion of $\pm .52$ mil vertical and $\pm .37$ mil horizontal. However, because of the unaccountably large dispersion in muzzle velocity, a vertical probable error, corrected for velocity, was calculated. A plot of vertical impact versus muzzle velocity is shown in Fig. 9. A correction factor determined by the least mean squares line, shown in Fig. 9, is 1.1819 in/fps. A vertical probable error of dispersion of $\pm .31$ mil is re-calculated with the use of the correction factor.

A similar group of projectiles will be fired for accuracy, from a tube rifled 1/20, in order to determine the effect of spin.

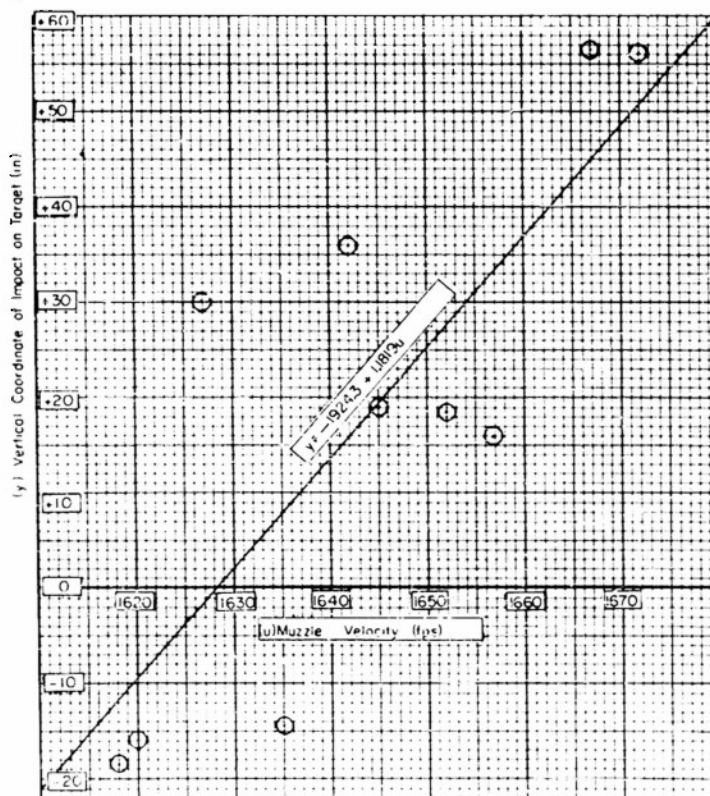


Fig. 9. Vertical Impact Versus Muzzle Velocity.
Least Mean Squares Line for Correction Of Vertical Impacts
for 10 T119E11X Projectiles.

Table I
Range Data
Accuracy Of T119E11X Projectile
With Short Fins and Two "O" Ring Observers

Date of Test: 8 March 1954
 Erie Ordnance Range

Purpose of Test: Accuracy of T119E11X with Short (6.92 in.) Fins
 Program: III

PROJECTILE

Model: T119E11X
 Type: Case
 Weight: 17.4 lb (Nom)
 CG Location: ---
 Bourlet Dia: 4.132 in.
 Spec: Features Short Fins (6.92 in. long)
 and 2 "O" Ring Observers
 Lot No: 5427-6

TEST GUN

Model: T119E11X
 Type: 105 mm Gun (105)
 Serial No: 37
 Chamber: 2.4 in. 54.1 in
 Bushing (Vent): 2.2 in 104.4
 Tube: 2.2 in 143.5 (Smooth Bore)
 Sighting Equipment: Gun Sight and M-17
 Mount: Elbow Telescope
 Type: Fixed Mount
 Serial: ---
 Zero Elevation Reading: 526 mils

MISCELLANEOUS DATA

Range Target: 980 y 403
 Propellant: Type MPM12 Web 0352a Weight 216.8 oz
 Lot No: PA 32259
 Primer: M67
 Shell Case: I 62 E1
 Line: DEC 479-1
 Temperatures: ---
 Magazine: ---
 Max 22.1° Min 21.9° Present 72.9°
 Loading Room 64.9° Ambient 40.9°

Round No	Proj No	Proj Weight (lb.)	Powder Charge (lb.-oz)	Wind Vel & Dir mph	Chamber Pressure (lb./sq in)	Muzzle Velocity ft/sec	Position of Hit (inches)	Corrected Position of Hit (inches)	Recoil (in)	Observations
6916-1	1362	17.50	7-8	2-45	9400	1672	1672	1672	1672	Warm Up Round Good Flight
6917-2	1847	17.44	7-8	4	9400	1672	1672	1672	1672	Good Flight Muzzle End Bracket
6918-3	1848	17.44	7-8	6	9400	1672	1672	1672	1672	Good Flight
6919-4	1855	17.45	7-8	6	9400	1672	1672	1672	1672	Good Flight
6920-5	1816	17.36	7-8	7	9400	1672	1672	1672	1672	Good Flight
6921-6	1853	17.44	7-8	7	9400	1672	1672	1672	1672	Good Flight
6922-7	1842	17.40	7-8	8	9400	1672	1672	1672	1672	Good Flight
6923-8	1850	17.42	7-8	7	9400	1672	1672	1672	1672	Good Flight
6924-9	1861	17.42	7-8	7	9400	1672	1672	1672	1672	Good Flight
6925-10	1852	17.40	7-8	4	9400	1672	1672	1672	1672	Good Flight
6926-11	1854	17.44	7-8	6	9400	1672	1672	1672	1672	Good Flight
6927-12	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6928-13	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6929-14	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6930-15	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6931-16	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6932-17	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6933-18	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6934-19	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6935-20	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6936-21	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6937-22	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6938-23	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6939-24	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6940-25	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6941-26	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6942-27	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6943-28	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6944-29	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6945-30	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6946-31	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6947-32	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6948-33	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6949-34	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6950-35	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6951-36	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6952-37	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6953-38	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6954-39	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6955-40	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6956-41	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6957-42	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6958-43	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6959-44	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6960-45	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6961-46	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6962-47	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6963-48	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6964-49	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6965-50	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6966-51	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6967-52	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6968-53	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6969-54	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6970-55	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6971-56	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6972-57	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6973-58	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6974-59	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6975-60	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6976-61	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6977-62	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6978-63	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6979-64	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6980-65	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6981-66	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6982-67	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6983-68	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6984-69	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6985-70	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6986-71	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6987-72	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6988-73	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6989-74	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6990-75	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6991-76	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6992-77	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6993-78	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6994-79	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6995-80	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6996-81	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6997-82	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6998-83	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
6999-84	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight
7000-85	1842	17.42	7-8	4	9400	1672	1672	1672	1672	Good Flight

Center of Impact: $V = 2.51 \text{ mil} \pm 1.503 \text{ mil}$

Probable Error - Vertical: ± 31 mil (Corrected for variation in muzzle velocity)

Prob: Director E. HUFFMAN
 Observers: R. ENGLISH
 L. S. KACBAK

Signed M. MANFREDI

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Accuracy Of T119E11 Projectile With Grooved Nose Cap

A grooved nose cap, shown in Fig. 10, has been tested for impact sensitivity, using T119E11 HEAT shell (see Fortieth Progress Report) and the effect of the grooved cap upon accuracy has now been determined.

Nineteen T119E11 projectiles with grooved nose caps were fired for accuracy at an 18 ft by 18 ft target at 1000 yards. The range data are given in Table II.

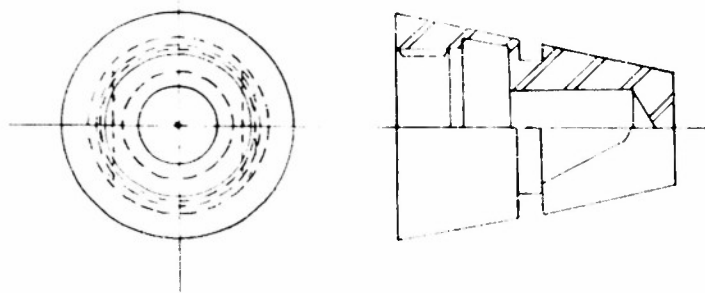


Fig. 10. Grooved Nose Cap.
Firestone Drawing DRA699.

Table II
Range Data
Accuracy Of T119E11X Projectile
With Grooved Nose Cap

Date of Test 11/24/44

Purpose of Test To Test Accuracy Of T119E11X Projectile With Grooved Nose Cap
Program 104

PROJECTILE

Model T119E11

Type Landing Fire

Weight 11.5 lb

CG Location

Borelet Dia 4.125 in

Special Features Grooved Nose Cap

TEST GUN

Model T119E11

Type 105 mm 6 Caliber

Serial No

Chamber 105 mm 6 Cal

Bushing (Venti) 105 mm

Tube 22 Caliber

Spring Equipment M17 105 mm

Muzzle Velocity 1600 ft/sec

Type

Serial

MISCELLANEOUS DATA

Range 1000 Yds

Projectile

Type T119E11X 105 mm 6 Caliber Weight 11.5 lb

Lot No 105 mm 6 Cal

Diameter

Shell Case

Liner

Temperatures

Moisture

Wind Min Present

Loading Room Ambient

Round No	Proj. No	Proj. Weight (lb)	Charge (lb)	Wind Vel (ft/sec)	Wind Dir	Chamber Pressure (psi)	Muzzle Velocity (ft/sec)	Total Time (sec)	Drift (in)	Position of Hit (in)	Corrected Position of Hit (in)	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	Remarks	
701	1	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
702	2	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
703	3	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
704	4	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
705	5	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
706	6	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
707	7	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
708	8	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
709	9	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
710	10	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
711	11	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
712	12	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
713	13	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
714	14	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
715	15	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
716	16	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
717	17	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
718	18	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
719	19	11.5	7.2	0	0	1200	1600	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Avg. 11.5										Avg. 11.5										Avg. 11.5									

Project No 104

Project No 104

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It was necessary to establish, by firing tests, the proper amount of interference between the stop and the housing. This interference is required to decelerate the fin opening action and to hold the fins open in flight. If the interference is too great, the fins do not open completely; and if the interference is too small, the inertia of the moving components may damage the fins when the stop reaches the limit of its travel.

Assemblies were made to determine, by firing tests, the permissible upper and lower limits of interference. Since the tolerance on the housing counterbore diameter is .004 in. and the tolerance on the stop interference diameter is .002 in., the range of interferences will be .006 in. Rather than manufacture new housings to determine the limits of interference, it was decided to use existing housings and to vary the diameters of the stops to produce the desired test interferences.

Three groups of assemblies, representative of tentative minimum diametral interferences of .006, .008 and .010 in., and three groups of assemblies representative of tentative maximum diametral interferences of .012, .014, and .016 in. were made. For the tentative maximum interference groups, 14S-T6 aluminum housings were used. The 14S-T6 material has been shown to offer greater resistance to full opening of the fins than does the alternative 24S-T4 aluminum. (See Fortieth Progress Report). The 24S-T4 material was used for the tentative minimum interference groups.

The extremes of the permissible piston-to-housing clearance were also incorporated in the tests. The fin assembly design tolerances permit piston-to-housing diametral clearances to vary from .001 to .007 in. Again, rather than manufacture new housings to the tolerance extremes of the base diameter, existing

housings were used and the diameters of the pistons were varied to produce the desired extremes of piston-to-housing clearance.

Pistons for the .001 in piston-to-housing clearance were made from existing pistons by adding excess cadmium plate to the piston diameter and grinding to the required diameter. The assemblies with a nominal .001 in piston-to-housing diametral clearance were hand fitted and were generally as tight a fit as could be assembled without force. These tight piston-to-housing fits were used with the maximum stop-to-housing interference groups.

Pistons for the .007 in. piston-to-housing diametral clearance were made from existing pistons by remachining to reduce the piston diameter and replating.

These loose piston-to-housings fits were used with the minimum stop-to-housing interference groups.

The rounds with fin assemblies, incorporating the maximum stop-to-housing interference groups, were loaded with the normal propellant charge. These rounds were stored in a cold box to bring the propellant temperature below -40°F, and they were then fired from the 106mm T170 El rifle. The rounds with fin assemblies, incorporating the minimum stop-to-housing interference groups, were loaded with a propellant charge to give 115 per cent of the maximum rated pressure. The rounds were fired at ambient temperatures. The firing data are shown in Table III.

Twenty rounds with a nominal .012 in. stop-to-housing interference were fired at temperatures below -40°F. Three of the fin assemblies failed to open completely. Examination of the recovered projectiles showed that the piston had galled in the housing base. The fits between housing and piston were very close in all cases and these pistons also had

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abnormally thick cadmium plating to provide the required minimum clearance. The thick cadmium plating contributed to galling which caused the failure of the fins to open completely.

Ten rounds with a nominal .014 in. interference between stop and housing and ten rounds with a nominal .016 in. interference between the same two components were fired at temperatures below -40°F . Nine of the fin assemblies with .014 in. interference opened completely and one opened partially. Four of the tail assemblies with .016 in. interference opened completely, five opened partially and one did not open at all. Again, a severe galling, which was attributed to the abnormally thick cadmium plating, was detected on the only round with a nominal .014 in. interference which did not open completely. These results indicated that the .014 in. interference was satisfactory. The rounds with a nominal .016 in. stop-to-housing interference gave a higher rate of failure to open completely, indicating that .016 in. interference is too great.

Ten rounds with a nominal stop-to-housing interference of .006 in., ten with a nominal interference of .008 in. and ten with a nominal interference of .010 in.

were fired with a propellant charge to give 115% of the maximum rated pressure at ambient temperature. Eight of the assemblies with .006 in. interference opened normally and two opened in excess of the designed spread. All twenty of the assemblies with .008 in and .010 in interference between stop and housing functioned normally.

It is evident from these results that an assembly of a housing made from 14S-T6 aluminum with a tapered stop which gives .016 in. interference will not consistently give complete fin opening, when fired at temperatures as low as -40°F . The test results also show that an assembly of a housing, made from 24S-T4 aluminum, with a tapered stop which gives a stop-housing interference of less than .006 in. may result in fin damage when the round is fired at 115% of maximum rated pressure.

An interference diameter of 1.824-.002 in. on the production stop, used with a housing counterbore diameter of $1.810 + .004$ in. will give interference limits of .008 in. to .014 in. These limits should permit consistent functioning of the tail assembly under the most extreme conditions of pressure to be encountered and with either housing material.

Table III
Range Data
To Determine Stop Interference Diameter
T119E1 Projectile

Date of Test: Dec 9, 1953
Dec 10, 1953
Jan 14, 1954

Purpose of Test: To Determine Stop Interference Dia
 Program: _____

PROJECTILE:
 Model: T119

Type: E11

Weight: 17.50 lb (Nom)

CG Location: _____

Borelet Dia: 4.32 in

Special Features: Max. and Min. Interferences in Tail Assy. During Production Stop
Dec 14, 1953

TEST GUN

Model: T170E1 (140)

Type: 106 mm Recoilless

Serial No: 51

Chamber: F-23

Bush (inglet): F-24

Tube: 2227-211-3

Sighting Equipment: M17 Elbow Sight

Mount: Proddum

Serial: _____

MISCELLANEOUS DATA

Range: Reservoir Box

Propellant: _____

Type: M10 MP With 1035 in Weight

Lot No: BA30287 (at least otherwise noted)

Primer: M-27

Shell Case: T123 E1

Liner: DA2477-1-12RC595 (3602/401)

Temperatures: _____

Magazine: _____

Max: 72°F Min: 72°F Present: 70°F

Loading Room: 53°F Ambient: 38°F

Round No	Proj No	Proj Weight (lb)	Powder Charge (lb-oz)	Muzzle Velocity (fps)	Chamber Pressure (psi. Cu.)	Temp (°F)	Fin Opening (in)	Shear Ring Thickness (in)	Stop-Housing Interference (in)	Piston-Housing Clearance (in)	Orifice Diameter (in)	Final Inspection and Observations
MAX INTERFERENCE (012) GROUP F120												
6503	X1729	17.56	7-12	1514	7000	-49	10 1/4 x 1/8	0.265	0.127	0.0075	.146	Normal Opening
6508	X1716	17.58	7-12	1532	7000	-48	10 1/4 x 1/8	0.260	0.124	0.006		Partial Opening
6505	X1713	17.58	7-12	1533	6800	-47	10 1/4 x 1/8	0.26	0.124	0.0075		Normal Opening
6506	X1714	17.54	7-12	1505	6000	-46	10 1/4 x 1/8	0.27	0.124	0.0075		Normal Opening
6507	X1714	17.54	7-12	1511	7000	-46	10 1/4 x 1/8	0.271	0.120	0.007		Normal Opening
6508	X1712	17.54	7-12	1515	7000	-44	10 1/4 x 1/8	0.275	0.127	0.0053		Normal Opening
6509	X1722	17.54	7-12	1527	7000	-44	10 1/4 x 1/8	0.280	0.117	0.008		Normal Opening
6510	X1711	17.56	7-12	1510	5100	-44	10 1/4 x 1/8	0.281	0.122	0.006		Normal Opening
6511	X1726	17.54	7-12	1514	5800	-45	10 1/4 x 1/8	0.275	0.128	0.012		Normal Opening
6512	X1726	17.54	7-12	1524	5800	-45	10 1/4 x 1/8	0.275	0.125	0.004		Normal Opening
MAX INTERFERENCE (012) GROUP F120												
6513	X1720	17.58	7-12	1509	5100	-60	9-9 x 1/8	0.245	0.129	0.0075	.146	Piston too far out of housing. Block 1035 at 120, 125, 126, 127, 128, 129
6514	X1725	17.55	7-3	1453	6400	-58	10 1/4 x 1/8	0.27	0.125	0.0056		Normal Opening
6515	X1728	17.54	7-3	1473	7000	-58	10 1/4 x 1/8	0.274	0.127	0.0050		Normal Opening
6516	X1729	17.54	7-3	1475	7000	-58	10 1/4 x 1/8	0.28	0.125	0.0060		Normal Opening
6517	X1723	17.55	7-3	1475	7200	-58	10 1/4 x 1/8	0.285	0.120	0.0060		Normal Opening
6518	X1730	17.56	7-12	1517	6000	-58	10 1/4 x 1/8	0.295	0.124	0.0085		Normal Opening
6519	X1717	17.54	7-3	1466	6000	-60	10 1/4 x 1/8	0.285	0.128	0.0035		Normal Opening
6520	X1727	17.56	7-3	1478	7000	-60	10 1/4 x 1/8	0.28	0.123	0.0075		Normal Opening
6521	X1718	17.56	7-12	1489	7200	-62	10 1/4 x 1/8	0.295	0.120	0.0070		Normal Opening
6522	X1715	17.56	7-12	1514	6000	-62	10 1/4 x 1/8	0.30	0.120	0.0070		Normal Opening
* 0385 PROPELLANT LOT PA 30252												

Center of Impact: _____
 Probable Error - Vertical: _____
 Probable Error - Horizontal: _____

Proof Director: E. HUFMAN
 Observer: S. FRANK

Signed: O. Miller

Serial of: _____

Table III (Cont'd)

Date of Test: Dec. 9, 1953
Dec. 10, 1953
Jan. 13, 1954
Jan. 14, 1954

Purpose of Test: To Determine Stop Interference Dis

Program

PROJECTILE

Model: T117

Type: F11

Weight: 17.50 lb. (Nom.)

CG Location

Borelet Dia: 4.132 in.

Special Features: Max. Min. Interferences in Tail Assy Using Production Stop WEA 141263-1

TEST GUN

Model: ILLUMIN (M40)

Type: Illumin. Recoilless

Serial No: 61

Chamber: F-23

Bushing(s): F-26

Tube: 220-S11-S

Sighting Equipment: M-17 Elbow Telescope

Mount: Pan du lun

Type: F-23

Serial

MISCELLANEOUS DATA

Range: Recovery Box

Propellant: M10MP Web 0.35 in Weight

Lot No: PA30259 unless otherwise

Primer: M-57

Shell Case: ILLUMIN

Liner: 220-S11-S; 0.0005 in (36 on/40)

Temperatures

Magazine

Max. 72°F Min. 70°F Present 70°F

Loading Room 65°F Ambient 39°F

Round No	Time of Flight	Proj Weight (lb.)	Powder Charge (lb-oz)	Muzzle Velocity (fps)	Chamber Pressure (psi. C.J.)	Temp (°F)	Fin Opening (in)	Shear Ring Thickness (in)	Stop-Housing Interference (in)	Aston-Housing Interference (in)	Orifice Diameter (in)	Final Inspection and Observations
MIN. INTERFERENCE												
6523	X1794	17.56	8-0	1692	9800	10300	11-11-11	0.28	0.051	0.075	0.197	Stop could be applied in by hand. Backlash 8
6524	X1797	17.53	8-0	1685	9800	10300	11-11-11	0.24	0.058	0.063	0.197	Stop could be applied in by hand. Backlash 8
6525	X1791	17.54	8-0	1674	9800	10300	11-11-11	0.20	0.055	0.050	0.197	Stop could be applied in by hand. Backlash 8
6526	X1796	17.55	8-0	1691	10200	10300	11-11-11	0.285	0.057	0.085	0.203	Fin assembly slightly tight. Piston had to be hammered out. Backlash 180-280. Stop could be applied in by hand. Backlash 8
6527	X1798	17.55	8-0	1677	10200	10300	11-11-11	0.24	0.050	0.061	0.197	Fin assembly slightly tight. Piston had to be hammered out. Backlash 180-280. Stop could be applied in by hand. Backlash 8
6528	X1750	17.56	8-0	1677	10200	10300	11-11-11	0.24	0.054	0.073	0.197	Fin assembly slightly tight. Piston had to be hammered out. Backlash 180-280. Stop could be applied in by hand. Backlash 8
6529	X1742	17.52	8-0	1691	9800	10300	11-11-11	0.27	0.058	0.063	0.197	Fin assembly slightly tight. Piston had to be hammered out. Backlash 180-280. Stop could be applied in by hand. Backlash 8
6530	X1745	17.54	8-0	1691	10200	10300	11-11-11	0.27	0.055	0.063	0.197	Fin assembly slightly tight. Piston had to be hammered out. Backlash 180-280. Stop could be applied in by hand. Backlash 8
6531	X1793	17.56	8-0	1677	9800	10300	11-11-11	0.27	0.053	0.071	0.201	Fin assembly slightly tight. Piston had to be hammered out. Backlash 180-280. Stop could be applied in by hand. Backlash 8
6532	X1797	17.54	8-0	1660	9800	10300	11-11-11	0.285	0.058	0.090	0.197	Fin assembly slightly tight. Piston had to be hammered out. Backlash 180-280. Stop could be applied in by hand. Backlash 8
MIN. INTERFERENCE												
6629	X1775	17.60	8-3	1688	9200	10300	11-11-11	0.245	0.079	0.081	0.196	Normal Opening
6630	X1783	17.59	8-3	1688	9200	10300	11-11-11	0.242	0.102	0.086	0.193	Normal Opening
6631	X1782	17.54	8-3	1671	9200	10300	11-11-11	0.242	0.100	0.089	0.193	Normal Opening
6632	X1777	17.58	8-3	1692	9200	10300	11-11-11	0.243	0.101	0.076	0.195	Normal Opening
6633	X1766	17.54	8-3	1701	10200	10300	11-11-11	0.251	0.077	0.070	0.195	Normal Opening
6634	X1773	17.61	8-3	1701	10200	10300	11-11-11	0.253	0.081	0.064	0.195	Normal Opening
6635	X1776	17.61	8-3	1702	9200	10300	11-11-11	0.255	0.102	0.070	0.193	Normal Opening
6636	X1767	17.54	8-3	1665	9200	10300	11-11-11	0.255	0.076	0.067	0.195	Normal Opening
6637	X1780	17.50	8-3	1704	9200	10300	11-11-11	0.255	0.095	0.061	0.195	Normal Opening
6638	X1768	17.63	8-3	1712	9200	10300	11-11-11	0.25	0.082	0.061	0.195	Normal Opening

Center of Impact
Probable Error - Vertical
Probable Error - Horizontal

Proof Director: E. Hoffman
Observers: E. F. L. Miller
Sheet 2 of 4

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Future Program

1. Accuracy firings are planned for the following three groups of projectiles.

(a) One group with short bodies, short ogives, rounded nose caps and T119E11 tail assemblies.

(b) One group with short bodies, long ogives, rounded nose caps, and T119E11 tail assemblies.

(c) One group with short bodies but otherwise standard T119E11 shell.

Groups (a), (b) and (c) will be tested

to determine the effect of variable body and ogive lengths on flight performance.

2. Projectiles with two "O" ring obturators will be fired from a rifled tube for spin both at the muzzle and at the target, and for accuracy at 1000 yards.

3. Twenty T119E11 projectiles with gilding metal obturating bands are being manufactured. These projectiles will be fired for accuracy using a smooth bore tube.

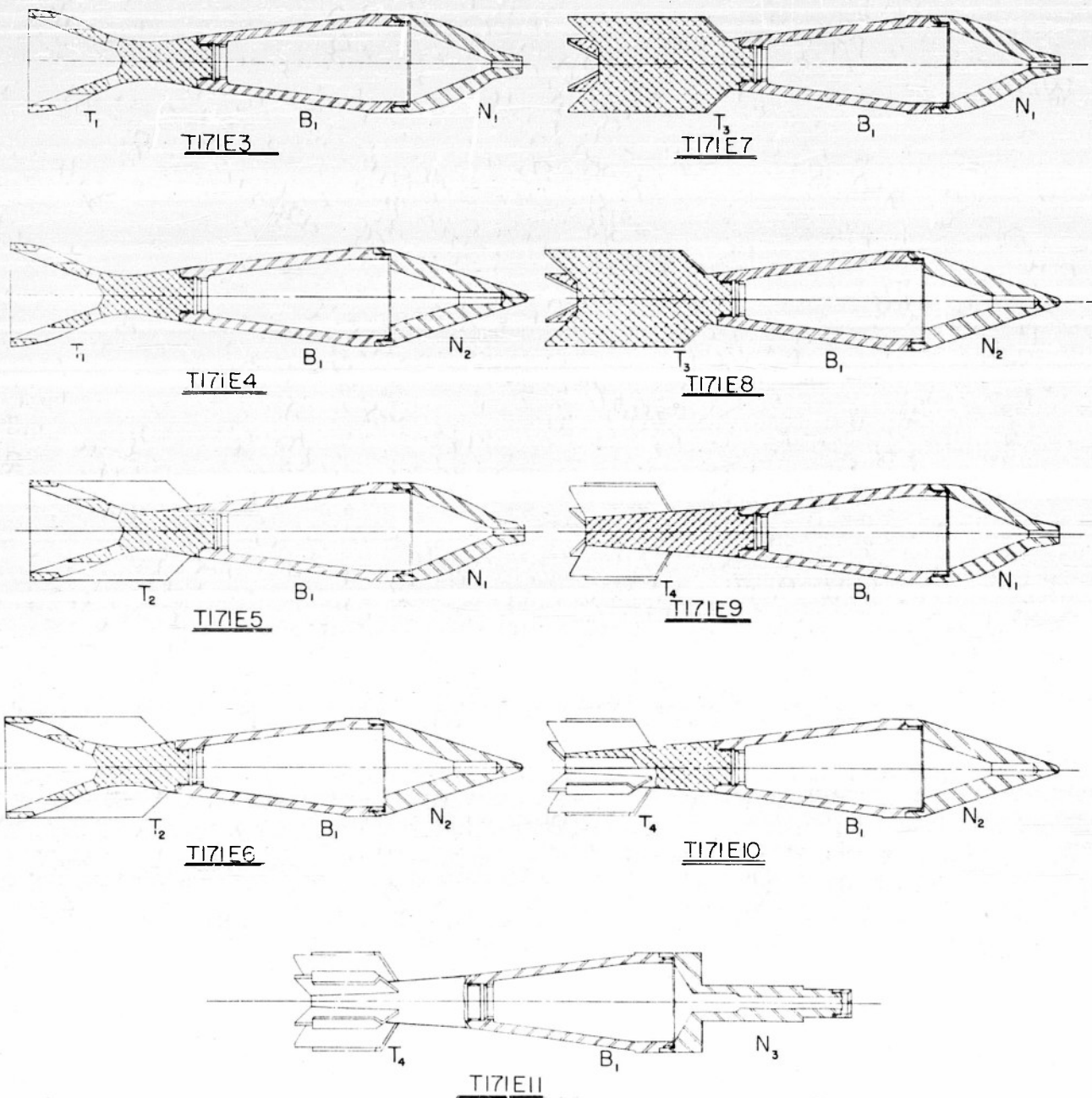
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T171 PROJECTILE

A change in nomenclature has been made for T171 projectile modifications. The letters MD, previously affixed to the modification number, have been replaced with the letter E; the numbers for the modifications remain the same.

Table IV contains the revised nomenclature for the T171 projectiles; Table V lists the symbols used and the component parts.

Table IV
Revised Nomenclature For T171 Projectiles



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Table V
Explanation Of Symbols
T171 Projectile Modifications

Symbol	Title	Drawing No.
N ₁	Smooth Nose	DRB182-2
N ₂	Conical Nose	DRB183-1
N ₃	Spike Nose	DRC328-1
B ₁	Body	DRC193-4
T ₁	Egg Cup Tail	DRC31-3
T ₂	Finned Egg Cup Tail	DRC175-2
T ₃	6-Finned Tail	DRC130-3
T ₄	6-Finned Tail, End-plated	DRC132-2

Accuracy Tests

Four T171 projectile accuracy programs were conducted at Erie Ordnance Depot. Three of these programs were with T171 E10 projectiles, and the fourth was with T171E11 projectiles. All of these rounds were equipped with nylon obturators (DRA 14-1281), which imparts a spin of approxi-

mately 19 rps (Forty-Third Progress Report). The projectiles were assembled in the shell cases as shown in Fig. 13 with the projectile seated at the obturating band, and the fins positioned with a nylon alignment ring, (DRA14-1280). A modified T19 rifle with a 1/20 twist tube was used for all firings, the target was 18 ft by 18 ft for all programs.

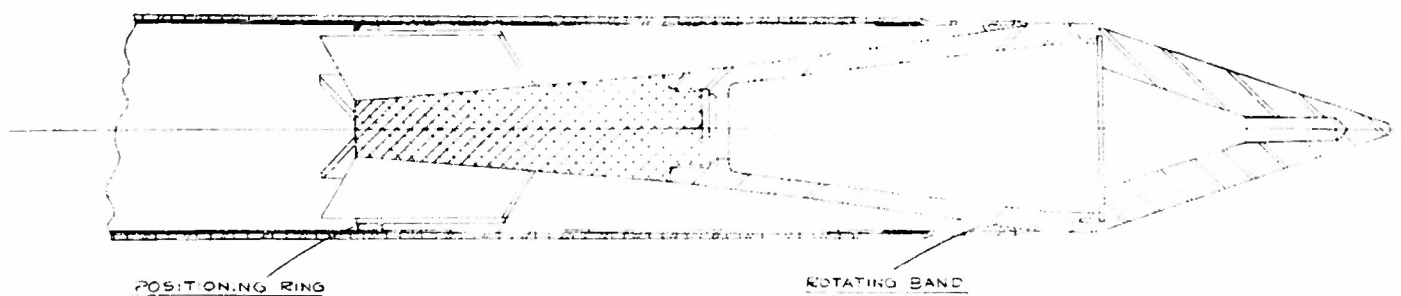


Fig. 13. T171 Projectile In Shell Case.

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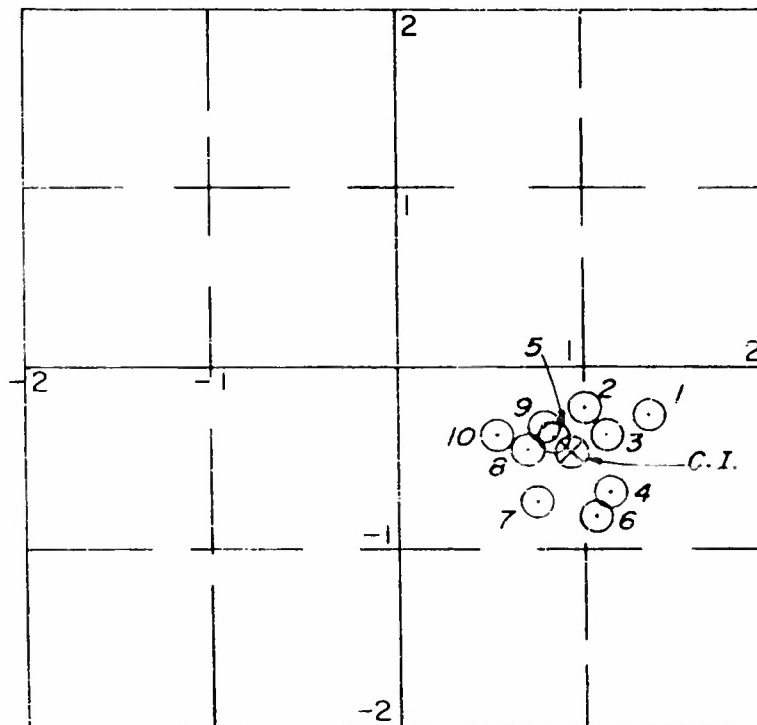
T171E10 At 1,000 Yards (T19 Rifle, Rigid Mount)

For this firing, the T19 rifle was placed on the rigid mount (Fig. 26, of the Forty-First Report). All ten rounds hit the target, giving probable errors of $\pm .17$ mil horizontally and $\pm .14$ mil vertically. This group of rounds, fired at an elevation of 23.5 mils and 1.2 mils left azimuth, with an average muzzle velocity of 1743 fps, had a center of impact .46 mil below, and .93 mil to the right of the center of the target. No correlation was found between vertical hit and muzzle velocity variation, or between horizontal hit and normal wind component, indicating that the dispersion of this group is larger than the effects of wind and velocity variation. The average retardation for this group of rounds is .221 fps/ft. The firing record for this program is found in Table VI, and the target plot is shown in Fig. 14.

T171E10 At 1,500 Yards (T19 Rifle, Rock Island Mount)

For this firing of ten rounds the T19 rifle was mounted on the Rock Island mount. The first round, fired at an elevation of 43 mils, hit 5 ft in front of the target. The elevation was raised to 45 mils and the remaining nine rounds hit the target, giving probable errors of $\pm .28$ mil horizontally and $\pm .40$ mil vertically. This group of rounds, fired at an elevation of 45 mils and average muzzle velocity of 1706 fps, had a center of impact .20 mil to the left of, and .61 mil above the target center (with azimuth reduced to 3 mils right).

The larger than expected vertical probable error is caused by round 9 falling below the rest of the group. An examination of the firing record shows that this round had a muzzle velocity 22 fps less than the average for the other eight rounds.



Center of Impact:	Horiz. = $\pm .93$ mil Vert. = $-.46$ mil	Probable Error:	Horiz. $\pm .17$ mil Vert. $\pm .14$ mil
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Fig. 14. Target Plot.
T171E10 At 1,000 Yards.

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This is shown clearly in Fig. 15, in which the vertical positions of the hits are plotted against muzzle velocities. Using the ballistic coefficient previously determined for this configuration (Thirty-Seventh Progress Report) the slope of the elevation muzzle velocity curve, for this velocity and range, is found to be .049 mil/ft/sec and is designated as line A in Fig. 15). Fitting a straight line to this data, (line B), a slope of .035 mil/ft/sec is obtained. It is then apparent that the primary reason for round 9 falling below the rest of the group is its low muzzle velo-

city. Using the slope of line A, the vertical probable error becomes $\pm .23$ mil; using the slope of line B, it is $\pm .30$ mil. It is not intended to imply here that either of these values represents the probable error of this program, but to show that the approximate vertical hit on the target could have been estimated had the muzzle velocity been known, and to indicate what the dispersion would be with more consistent muzzle velocities. The firing record for this program is shown in Table VII; the target plot is illustrated in Fig. 16.

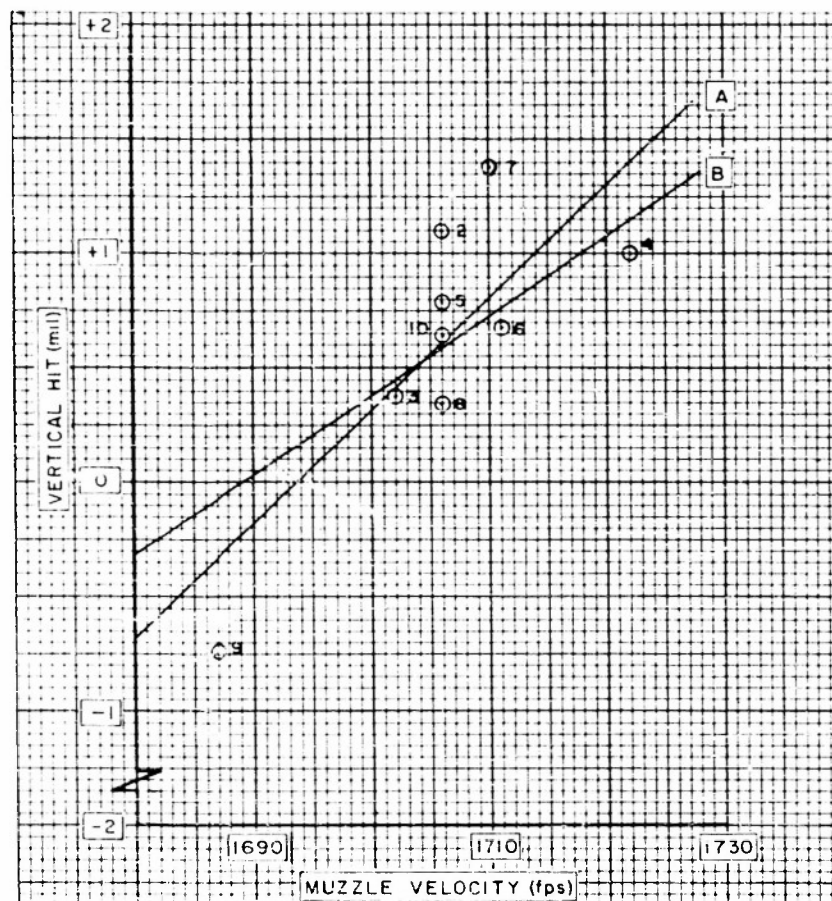


Fig. 15. Vertical Hits Versus Muzzle Velocity.
T171E10 At 1,500 Yards.

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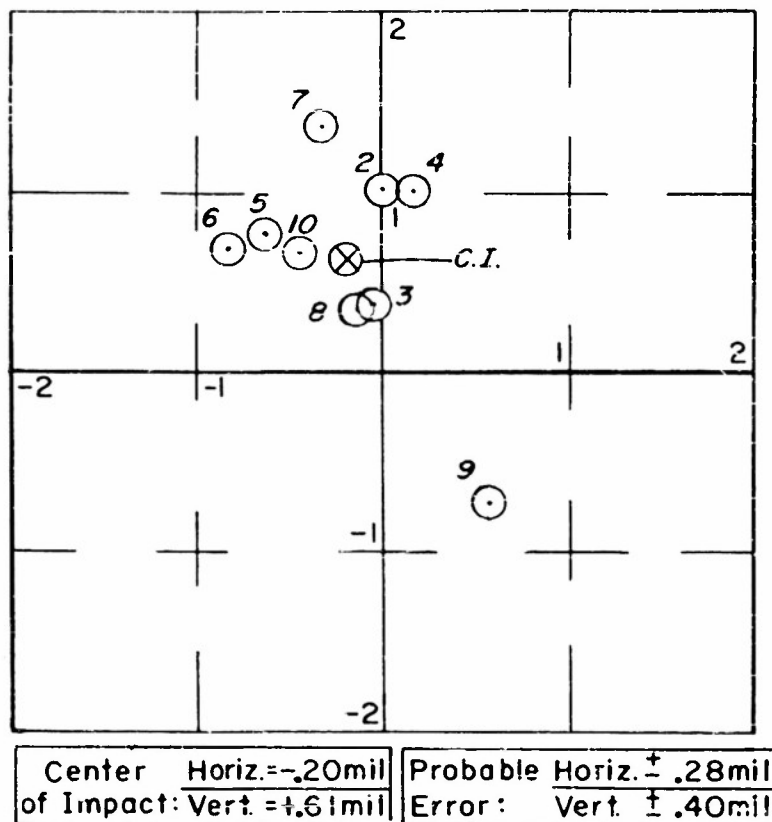


Fig. 16. Target Plot.
T171E10 At 1,500 Yards.

T171E11 At 1,000 Yards (T19 Rifle, Rock Island Mount)

One T171 E11 projectile was fired from the T19 rifle mounted on the rigid mount, and it hit one mil from the left edge of the target. The rifle was then moved to the Rock Island mount, so that it would be possible to compensate for wind variations by changing azimuth. The remaining ten projectiles hit the target, giving probable errors of $\pm .11$ mil horizontally and $\pm .30$ mil vertically. This group of rounds, fired with average muzzle velocity of 1708 fps, had a center of impact .18 mil above and 1.15 mils to the right of the target center, (when hits are reduced to an elevation of 24.7 mils and 2 mils right azimuth). No correlation of target hits with wind velocity or muzzle velocity was found. The firing record is in Table VIII and the target plot is shown in Fig. 17.

T171E10 At 1,000 Yards (T19 Rifle, Rock Island Mount)

This program of 10 rounds was fired with the T19 rifle mounted on the Rock Island mount. All ten rounds hit the target, giving probable errors of $\pm .38$ mil horizontally and $\pm .26$ mil vertically. This group of rounds, fired with an average muzzle velocity of 1757 fps, had a center of impact, .01 mil below and 1.21 mils to the left of the target center, (when target hits are reduced to 22.5 mils elevation and zero azimuth).

The high horizontal probable error can be attributed to the varying wind velocity. The horizontal impact is shown plotted against normal wind component in Fig. 18. The slope of the least squares line fit to these data is .090 mil per mile per hour. Reducing the horizontal impacts to zero wind velocity, a probable

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error of $\pm .27$ mil results, which is in closer agreement with the results of the previous T171 E10 firing at 1000 yards.

The firing record is in Table IX and Fig. 19 is the target plot.

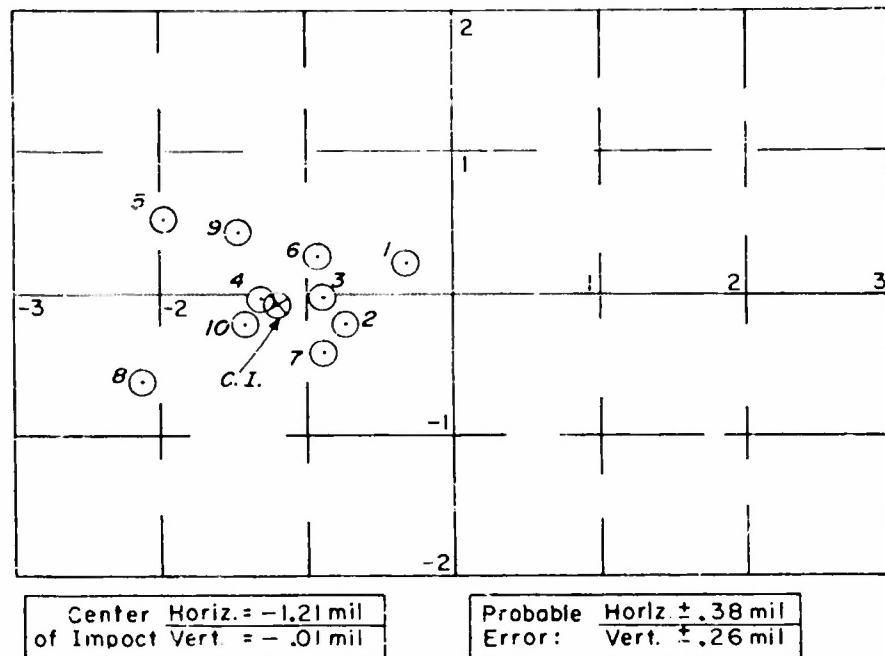


Fig. 17. Target Plot.
T171E11 At 1,000 Yards.

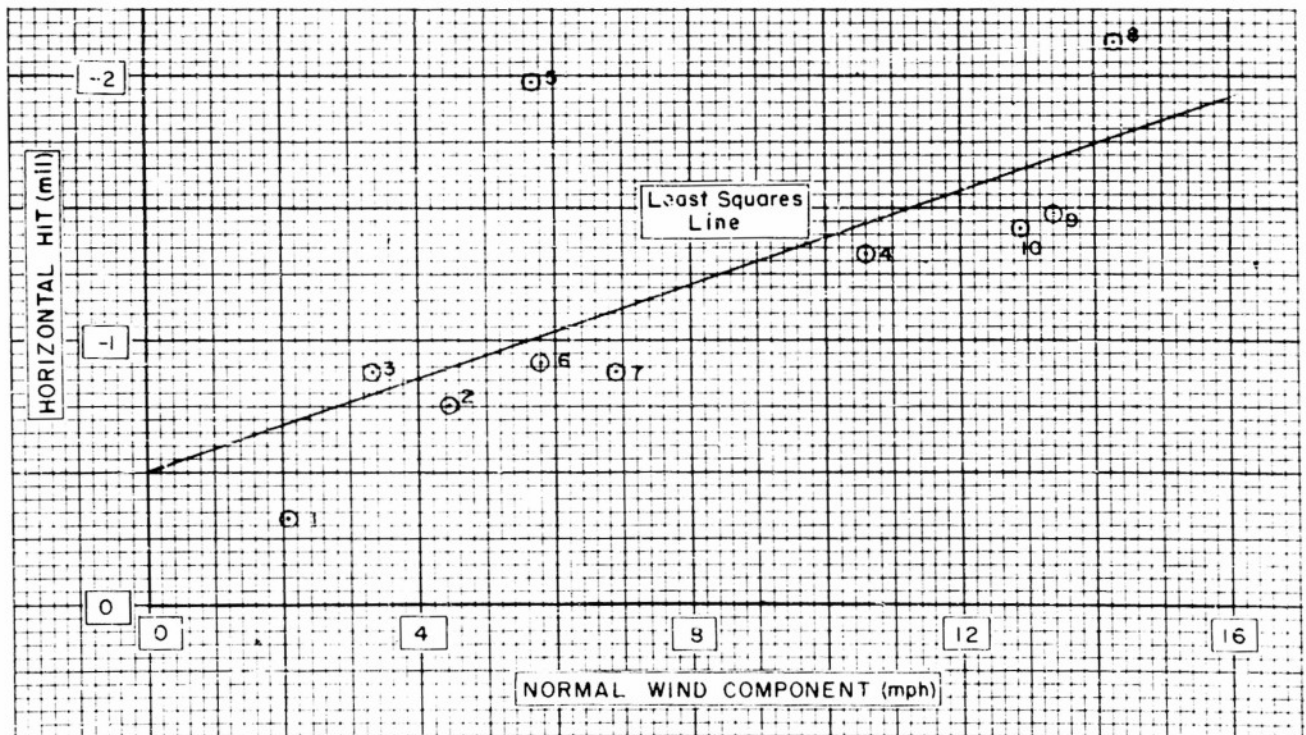


Fig. 18. Horizontal Impact Vs. Normal Wind Component.

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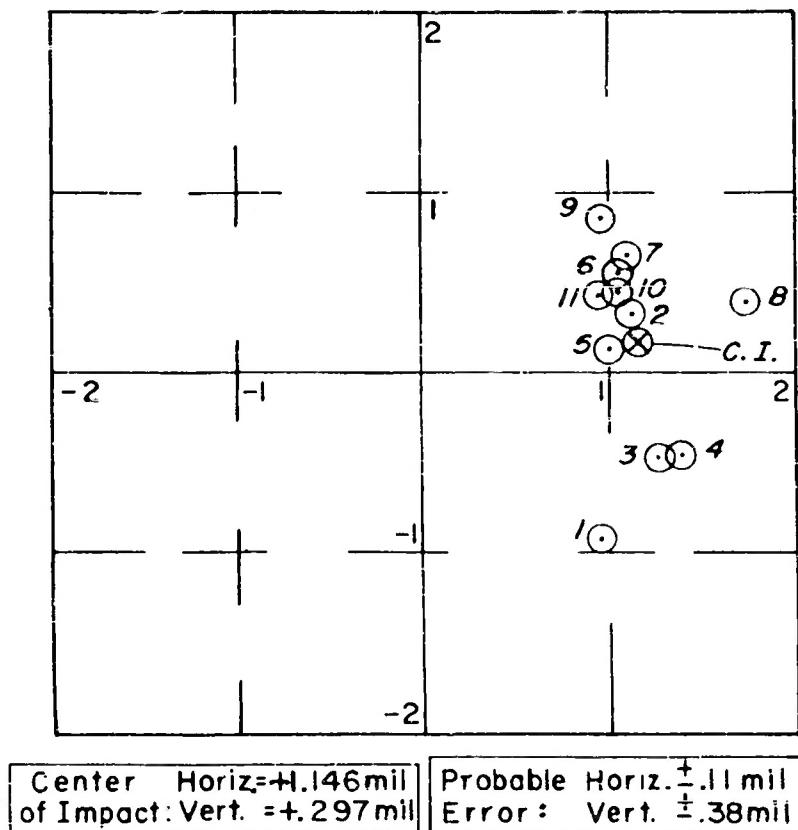


Fig. 19. Target Plot.
T171E10 At 1,000 Yards.

Future Program

1. Determine accuracy of T171E10 projectile, as shown in Fig. 13 at 2000 yard range.
2. Determine roll damping rate of T171
- projectiles for ranges of 1000 yards and 1500 yards.
3. Design and test T171 projectiles with increased ogive length.

Table VI
Range Data
To Determine Accuracy and Flight Characteristics
T171E10 Projectile At 1,000 Yards

Date of Test March 10, 1954
First and Second
Purpose of Test To Determine Accuracy and Flight Characteristics
of T171E10

PROJECTILE

Model T171
Type E10
Weight 17.5 lb (No m)
Retardation 0.22 fps/ft
Borelet Dia 4.132 in
Special Features None
Air Density 1.225 x 10⁻³ g/cc
Rounds loaded as single unit

TEST GUN

4th Model T19
Type 105mm Recoilless Rifle
Serial No 6
Chamber 26094-1-12931
Bushing (Vent) 2230826
Tube 2532-7-12162 (1/20 Twist)
Sighting Equipment Boresight Telescope M17
Mount Sumner Quadrant M1
Type Base (Concrete Base)
Serial 1
Firing Subsized Rds 1-4, Electric Rds 7-10

MISCELLANEOUS DATA

Range 1000 yd Target
Propellant Type M101MP W60.035in. Weight 8.160oz
Lot No PA 30259
Primer M57 (13in. Twist)
Shell Case T53E1
Liner T6 spccm
Temperatures
Magazine 73°F Min 71°F Present 71°F
Max 73°F Ambient 37°F
Loading Room 60°F

Round No	Proj. No.	Proj. Weight (lb.)	Powder Charge (lb-oz)	Wind Vel & Dir. (mph)	Chamber Pressure (cu) (lb/50 in ²)	Muzzle Velocity (ft/sec)		Elevation (mil)	Position of Hit (inches)			Corrected Position of Hit - mils		Yaw (in.)	Observations
						Instr.	Actual		Vert	Horiz	Vert	Horiz	Vert		
6927	654	17.53	8-0	8-000	10,000	1747	1747	-24 58-235	-7 1/2	+3 1/2	-0.251	+1.354	-0.251	4 1/2 x 4 1/2	M17 Hy-mulch before firing - 1.2 (L) with 3000
6928	634	17.52		8-345	9900	1746	1746		-13 1/2	+40 1/2	-0.377	+1.131	-0.377	4 1/2 x 4 1/2	Mistaken Skinned firing spring and retired
6929	724	17.51		8-355	9800	1740	1740		-24 1/2	+41 1/2	-0.486	+1.159	-0.486	4 1/2 x 4 1/2	
6930	644	17.51		8-005	10,100	1752	1752		-14	+30 1/2	-0.391	+0.852	-0.391	4 1/2 x 4 1/2	
6931	614	17.57		11-015	10,200	1758	1758		-29	+38 1/2	-0.810	+1.082	-0.810	4 1/2 x 4 1/2	
6932	554	17.52		12-020	10,300	1748	1748		-26 1/2	+27 1/2	-0.740	+0.748	-0.740	4 1/2 x 4 1/2	Mistaken New firing pin.
6933	744	17.51		11-010	10,300	1748	1748		-16 1/2	+25	-0.461	+0.461	-0.461	4 1/2 x 4 1/2	
6934	694	17.54		7-340	9800	1733	1733		-11	+28 1/2	-0.307	+0.796	-0.307	4 1/2 x 4 1/2	
6935	704	17.55		8-000	9500	1751	1751		-12 1/2	+19	-0.349	+0.530	-0.349	4 1/2 x 4 1/2	
6936	684	17.53			9400	1748	1748								Good flight for all rounds
Averages		17.53													• No appreciable Yaw • No hit included in average

Center of Impact V = 4.58 mil/1/2, 1/2, 1/2
Probable Error - Vertical ± 0.14 84
Probable Error - Horizontal ± 0.17 84

Proof Director E. Huffman Signed W. McMillan
Observer W. O. Davies
Lytle, June 24

Table VII
Range Data
To Determine Accuracy and Flight Characteristics
T17E10 Projectile At 1,500 Yards

PROJECTILE
Model T17E10
Type E10
Weight 17.5 lb (Nom)
Retardation 0.221 ft/sec²
Barrel Dia 4.13 in
Special Features None
Base Line Slope to 1500 Yd Target 4422.36'

TEST GUN
Model T19
Type 105mm Recoilless Rifle
Serial No 6
Chamber 26690-1-12931
Bushing(Vent) 7230826
Tube 2532-7-12162
Sighting Equipment Electronic Telescope, M17, Bore Sight, Gunners Quadrant, M1
Mount M75
Type 541
Serial 541
Fired Electrically

MISCELLANEOUS DATA
Range 1500 Yd
Propellant 30 grains from Remington-Union
Type M10MP Web-035 in Weight 716.103
Lot No PA30259
Primer M39113 in 103
Shell Case T53E1
Liner 76 Special
Temperatures
Magazine 71°F Min 71°F Present 71°F
Max 73°F Ambient 58°F
Loading Room

TEST DATA
Date of Test March 14, 1958
Fire Ord Depot
Gun 1st 49.4' 47.43' 95' 2nd
Velocity Coils

Proj No	Proj Weight (lb.)	Powder Charge (lb. oz)	Wind Vel & Dir (mph deg)	Chamber Pressure (lb./sq. in.)	Muzzle Velocity (ft/sec)	Actual Instr	Elevation (mils)	Position of Hit (inches)	Corrected Position of Hit (mils)	Yaw (in)	Observations
							zero	super	Vert	Horiz	
6937	17.53	7-14	9 085	8700	1774	1690	1.1 R	2.9 - 43.0			Missed, hit 5 ft short of target - 118V - 72M
6938	17.50		8 065	9600	1690	1690	1.1 R	2.9 - 45.0	+10.8	+0.013	4 1/2 x
6939	17.53		12 075	9700	1686	1702	+3 R	2.9 - 45.0	+2.0	+0.360	4 1/2 x
6940	17.54		8 080	9300	1706	1722	+3 R	2.9 - 45.0	+5.0	+0.994	4 1/2 x 1/2
6941	17.52		15 070	9500	1690	1706	+3 R	2.9 - 45.0	+42 1/2	+0.782	4 1/2 x 1/2
6942	17.53		13 080	9300	1695	1711	+3 R	2.9 - 45.0	+36 1/2	+0.672	4 1/2 x 1/2
6943	17.54		15 065	8900	1644	1710	+3 R	2.9 - 45.0	+7.4	+1.362	4 1/2 x 1/2
6944	17.55		14 065	9900	1690	1706	+3 R	2.9 - 45.0	+18 1/2	-9	5 x
6945	17.54		14 065	9200	1671	1681	+3 R	2.9 - 45.0	-39 1/2	+29 1/2	5 1/2 x
6946	17.53		13 055	8800	1689	1705	+3 R	2.9 - 45.0	+35	+0.640	1/2 in of fin showing on target panel
Averages						1705					Good flight on all rounds. All rounds landed at single units.

Center of Impact V + 0.766; H - 0.197 mi.
Probable Error - Vertical ± 0.40 84
Probable Error - Horizontal ± 0.28 RMS

Proof Director E. Hoffman Signed W. M. Million
Observers W. O. Davies
L. Swartz

Table VIII
Range Data
To Determine Accuracy and Flight Characteristics
T171E:1 Projectile At 1,500 Yards

Date of Test 11 March 1954
 Purpose of Test To Determine Accuracy and Flight Characteristics of T171E:1 Projectile

PROJECTILEModel T171Type E1Weight 17.38 lbCG Location Barrel Dia 4.132 inSpecial Features No Special FeaturesAverage Refraction 0.016 Ft/Sec/Ft

Electric Firing

Line of Fire: 28° Measured Clockwise from Magnetic North**TEST GUN**Model T19Type 203mm RecoillessSerial No 6Chamber 26694-1-12931Bushing 7230826Tube FGE 2532-1-12162Mount Standard Gunner's M11 No. 12225Type RecoillessSerial RA 211105mm Rifle M75**MISCELLANEOUS DATA**All Air Density Readings 1.227410Range 1000 ftType MP M10Lot No PA 30253Primer 1325b M37Shell Case T53 ModifiedLiner T-6 Special

Temperatures in Degrees F:

Magazine 73Max 71Loading Room 62Present 71Ambient 38

Round No	Projectile Number	Proj Weight (lb.)	Powder Charge (lb. oz.)	Wind Vel & Dir (mph - degree)	Chamber Pressure (lb./sq in)	Muzzle Velocity ft/sec		Azimuth (mil)	Elevation (mil)	Position of Hit (ft)		Corrected Position of Hit - mils		Yaw (mil)	Observations	
						instr	actual			west	height	vert	range			
6947	1	26	17.38	7-14 13	065	9000	1709	0.0	6.7	24.7	-33 1/2	3/	-0.930	0.962	No A.Y. 0	Lost on Target. Changed Mounts. Not Used in Computation of P.E.
6948	2	23	17.38	7-14 18	055	9500	1726	0.00R	6.7	24.7	12	7.8	0.335	1.177	1 1/2 x 4 1/2	
6949	3	24	17.38	7-14 18	065	9300	1675	0.20R	6.7	24.7	17	0.5 1/2	-0.475	1.270	4 3/4 x 4 1/2	
6950	4	27	17.39	7-14 16	060	9300	1701	0.20R	6.7	24.7	16 1/2	0.77 1/2	-0.461	1.392	4 3/4 x 4 1/2	
6951	5	24	17.37	7-14 12	065	9100	1704	0.20R	6.7	24.7	5	1	0.140	1.605	No A.Y. 0	
6952	6	34	17.38	7-14 16	070	9300	1721	0.20R	6.7	24.7	2 1/2	1.3	0.572	1.641	Target Measure	
6953	7	25	17.38	7-14 16	075	9500	1716	0.20R	6.7	24.7	23 1/4	0.34 1/2	0.64	1.112	4 1/2 x 4 1/2	
6954	8	23	17.38	7-14 16	055	9100	1704	0.20R	6.7	24.7	14 1/2	0.52 1/2	0.405	1.465	No A.Y. 0	
6955	9	30	17.38	7-14 10	060	9400	1718	0.20R	6.7	24.7	32	0.35	0.893	0.717	4 3/4 x 4 1/2	
6956	10	32	17.38	7-14 18	060	9300	1707	0.20R	6.7	24.7	11 1/2	0.38	0.441	1.061	Target Measure	Bit setting opening set at 0.743" - 0.744" with Std. built using flats of hole as measurement
6957	11	31	17.38	7-14 20	060	9100	1706	0.20R	6.7	24.7	16	0.34 1/2	0.417	0.963	Target Measure	Slight lean on target. Set column to left
Averages		17.38				9190				Total 31.4						Good flight on all rounds 0 No A.Y. = No Appreciable Yaw
One of these should be 33																

Center of Impact V-0297, H-1146
 Probable Error - Vertical ± 0.30 mi
 Probable Error - Horizontal ± 0.21 mi

Prod Director: Edward Hoisington
 Observer: W.O. Davies

Signed 11 March 1954

Table IX
Range Data
To Determine Accuracy and Flight Characteristics
T171E10 Projectile At 1,000 Yards

Date of Test 18 March 54
 Eric Ordinance Depot

Purpose of Test To Determine Accuracy and Flight Characteristics
 Program 109 OF T171E10

PROJECTILE

Model T171E10
 Type EXERCISE PROJECTILE
 Weight 17.53 lbs (Nom)
 CG Location ---
 Bourlet Dia 4.32 in.
 Special Features None

TEST GUN

Model T19
 Type 105mm Recoilless
 Serial No 6
 Chamber 26484-1-12931
 Bushing VENTILATOR (2300426)
 Tube 12782-2455-2 (1-20 twist)
 Sighting Equipment Quadrant MI No. 113243
 Mount M17 Elbow Telescope No. 122275
 Type 20 Power Scope, Gene Sight Case
 Serial 105mm Rifle 1235

MISCELLANEOUS DATA

Range 984.9 yds
 Propellant Type MP20A Web 0.085 Weight 216-1812
 Lot No FA90383
 Primer 13111 M47
 Shell Case T-2 Modified
 Liner T-4 Special
 Temperatures
 Magazine Max 23°F Min 71°F Present 72°F
 Loading Room 62°F Ambient 66°F

Retardation: 0.22 ft/sec/ft. Electric Firing System.

Round No	Proj No	Proj Weight (lb.)	Powder Charge (lb.-oz)	Wind Vel & Dir	Chamber Pressure (lb./sq in)	Muzzle Velocity (ft/sec)	Azim (mils)	Elevation (mils)	Position of Hit		Corrected Position of Hit - mils		Time Of Flight (sec)	Observations
									Ver	Horiz	Ver	Horiz		
6976-1	49H	17.50	7-14	7 195	10100	1749	0.0	76	245	+80	-0.234	-0.385	2.08046	On M17 Scope +0.2 Azim, (R)
6977-2	48H	17.52	7-14	5 145	10100	1744	0.0	76	235	+28	-0.210	-0.754	2.09488	
6978-3	53H	17.53	7-14	9 050	9000	1750	0.0	76	235	+34 1/2	-0.037	-0.819	---	
6979-4	54H	17.53	7-14	12 090	10100	1741	0.0	76	235	+38 1/2	-0.037	-1.340	---	
6980-5	51H	17.55	7-14	6 100	10300	1745	0.0	76	225	+19	-0.231	-1.996	2.09359	
6981-6	46H	17.52	7-14	11 060	9900	1751	0.0	76	225	+10 1/2	+0.293	-0.921	---	
6982-7	45H	17.53	7-14	18 060	9400	1746	0.0	76	225	-15	-0.419	-0.873	2.10093	
6983-8	52H	17.53	7-14	16 090	9600	1737	0.0	76	225	-24	-0.670	-2.136	2.10804	
6984-9	50H	17.52	7-14	17 080	10200	1747	0.0	76	225	+16	+0.447	-1.495	---	
6985-10	47H	17.53	7-14	14 095	10000	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6986-11	46H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6987-12	45H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6988-13	44H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6989-14	43H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6990-15	42H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6991-16	41H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6992-17	40H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6993-18	39H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6994-19	38H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6995-20	37H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6996-21	36H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6997-22	35H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6998-23	34H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
6999-24	33H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	
7000-25	32H	17.53	7-14	14 095	9900	1734	0.0	76	225	-7 1/2	-0.209	-1.433	---	

Cent of Impact V=0.000; H=+1.218

Probable Error - Vertical ± 0.26 mil East Mean Square ± 0.27 mil
 Probable Error - Horizontal ± 0.38 mil East Mean Square ± 0.27 mil Corrected for Wind Only

Proof Director E. HUBERMAN Signed William M. McMillan
 Observers Col Butler, Maxima, Wirth,
Stadler, Miller, Cox, Sweeney, Davies,
Coppler, Manaksky.

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T120 PROJECTILE

Dynamic Tests Of Compensating Liners

The problem of dynamically determining the performance of projectiles with spin compensating cones presents some unusual difficulties. The projectile must have a target spin equal to the optimum spin rate of the liner being tested, must not interfere with or reduce the penetration and must have a reliably accurate flight for at least 400 to 600 ft at spin rates ranging from about 25 rps to 100 rps. The actual spin rate in any one test is determined by the cone whose performance is being evaluated.

The T138E57 projectile would seem to be an excellent choice except that the present tee design does not provide enough free space in front of the cone and the penetration is reduced. A new tee could be designed but since an adequate number of metal parts already exist this procedure is not an attractive one. Therefore, a cylindrical section has been de-

signed for the T138E57 projectile which will fit between the tee and body of the present design and provide the added clearance required for penetration. Sleeves are being made and accuracy tests are planned.

A sufficient number of T119E11 projectile components are also available for use in dynamic penetration tests. However, the fins need to be redesigned so as to have an equilibrium spin rate equal to the desired target spin rate and the projectiles need to be fitted with rotating bands so that the shell can be fired from a suitably rifled tube at the spin rate being tested. Because of the large torque applied to the projectile by the rifling the fins would need to be strengthened. This can be accomplished conveniently by shortening the fins. Five T119E10 projectiles have been equipped with modified fins shortened to 4.93 inches and twisted to have an effective cant angle of 2.105° (DRD-14-489-3). The assembled projectile is shown in Fig. 20. These

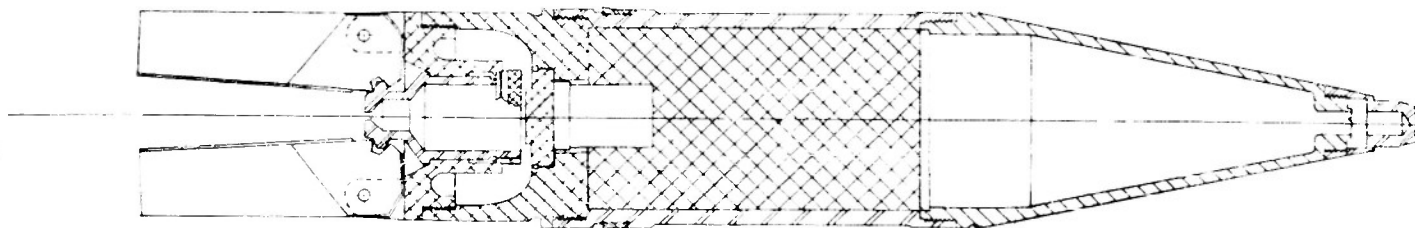


Fig. 20. T119E10 Projectile With Modified Fins.

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five projectiles were fired from a T137 E3 rifle equipped with a tube with a 1/80 twist so as to have a muzzle spin rate of 60 rps at 1700 fps. Four projectiles were fired through yaw cards for spin determination, two at screens approximately 100 ft from the muzzle and two approximately 496 ft from the muzzle. The spin data are shown in Fig. 21 and Table X shows the firing record. The fifth projectile was equipped with a blunt nose

and was fired through yaw cards into the recovery box. No evidence of fin damage was observed. None of the projectiles had any severe yaw but did have a noticeable right drift.

These data show that the fins were not canted sufficiently to maintain the muzzle spin and further tests are planned with fins canted approximately 3° and 4° .

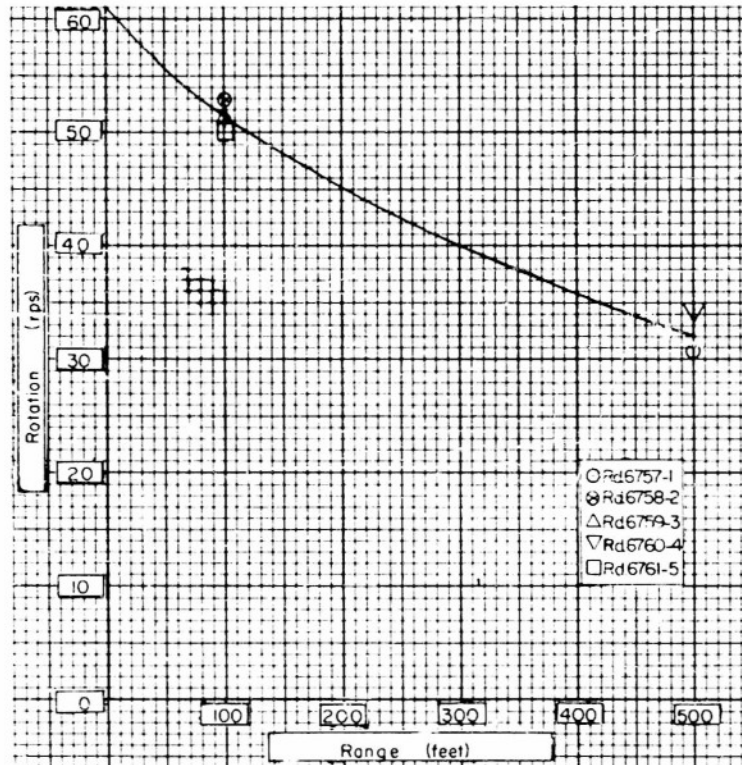


Fig. 21. Spin Data.
RPS Versus Range.

Table X
Range Data
T119 Projectile With Short, Canted Fins

PROJECTILE										RANGE DATA										MISCELLANEOUS DATA									
Model T119-1										Purpose of Test T119 SHORT FIN ACCURACY (SEE 27)										Range 500 ft (approx) 50m - 50m target									
Type Fin Stabilized										Program										Propellant									
Weight 1760 lb (Nim)										Type T119-1										Type M101 W80222 N101 B16									
C.G. Location										Serial No. 6										Lot No. 1280254									
Barrellet Dia 4.122 in.										Character 220-481-0-A										Primer M57									
Special Features Short Fins Retaining Blends										Bushing (W80222) 0-270 (220-481-0-A)										Shell Case T2261									
										Tube 220 345 E 1/80 Twist										Liner DRC 474									
										Sighting Equipment T119 Minut Telescope No 9										Magazine									
										Mount										Max 23.2° Min 71.0° Present 22.2°									
										Type T119-1										Loading Room 610° Ambient 25.0°									
										Serial										Observations									
										Target 28° Clockwise from magnetic North, Solenoid fired										Hit Target									
																				Missed Target Nicked right edge									
																				Hit right edge of target									
																				Hit Target									
																				Blunt nose replaced with new wing									
																				1700 lb fired into recovery box									
																				Note Charge was increased from 14-1442									
																				To B-0 to give desired velocity									
																				Last round was fired into recovery box									
																				To check fins									

Date of Test 28 January 1950										Type T119-1										Serial No. 6										Character 220-481-0-A										Bushing (W80222) 0-270 (220-481-0-A)										Tube 220 345 E 1/80 Twist										Sighting Equipment T119 Minut Telescope No 9										Mount										Type T119-1										Serial										Target 28° Clockwise from magnetic North, Solenoid fired																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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YAW CARD DISTANCES									
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Double Body Projectiles

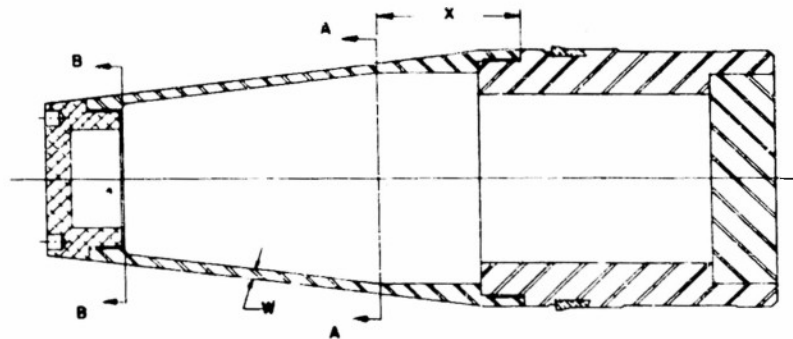
Various methods for reducing the weight of the double body projectile (Supplement to the Thirty-Seventh Progress Report) from 24 lb to 17.5 lb have been considered. One of the methods considered was to reduce the wall thickness of the non-rotating body. It was considered desirable to determine the minimum permissible wall thickness. Pages 49 and 50 of the Forty-First Progress Report presents results of firing tests using projectile bodies with wall thicknesses of .220, .180, and .140 in. The latter of these represents a decrease in wall thickness of 17.9% and a decrease in rear body weight of 44%. It was reported that none of these test bodies failed and further tests have now been conducted.

Strength Of "Non-Rotated" Body

In the present experiment six test bodies were fired with wall thicknesses of .120, .080, and .060 in. These are shown in Fig. 22. Their weight was adjusted to 17 lb and they were equipped with rotating bands. A modified T19 rifle with 1/20 twist tube was used for the test.

Nominal muzzle velocity of 1700-1750 fps was specified. Table XI is the firing record for the test. All rounds showed some degree of failure as shown by pictures, Fig. 23. Stress analysis calculations have been made and the data are presented in Fig. 22. The data disclose the fact that these projectiles were all overstressed and should fail in the observed fashion. However, it should be pointed out that even though the setback calculations for projectiles TS-39 thru TS-44, as reported in the Forty-First Progress Report, clearly showed a marginal safety factor, and that no visible signs of failure were found, a complete stress analysis was not made until completion of this program. The results of the combined stresses as plotted against wall thickness, Fig. 24, now show that even the .140 in wall has borderline strength and therefore a minimum wall thickness greater than .140 in must be selected.

A sample calculation made at sect. B-B indicated the resultant stress would be lower here than at sect. A-A, therefore, stress calculation at this section for remaining rounds were not made.



Proj. Number	Body, Rear	Wall (W) Thick. (in.)	Stress Calculations (psi)			Sect A-A Resultant	X (in.)	Stress Calculations (psi)			Sect B-B Resultant
			Set-back	Hoop	Radial			Set-back	Hoop	Radial	
TS-43	DRC-643	.220	29,200	76,840	11,000	58,000	1.67				
TS-40	DRC-642	.180	35,800	96,008	11,700	78,000	2.00				
TS-44	DRC-641	.140	47,150	123,835	12,705	115,000	2.33				
TS-45	DRC-22-766	.120	75,550	148,125	13,380	121,000	2.49	72,550	87,655	11,380	70,000
TS-46	DRC-22-766	.120	78,500	159,150	13,980	128,000	2.49				
TS-47	DRC-22-767	.080	120,700	195,020	12,670	160,000	2.82				
TS-48	DRC-22-767	.080	140,500	228,220	15,000	172,000	2.82				
TS-50	DRC-22-769	.060	145,400	279,385	13,440	224,000	2.99				

Fig. 22. Test Slug.
To Evaluate Wall Thickness Of After-Body.

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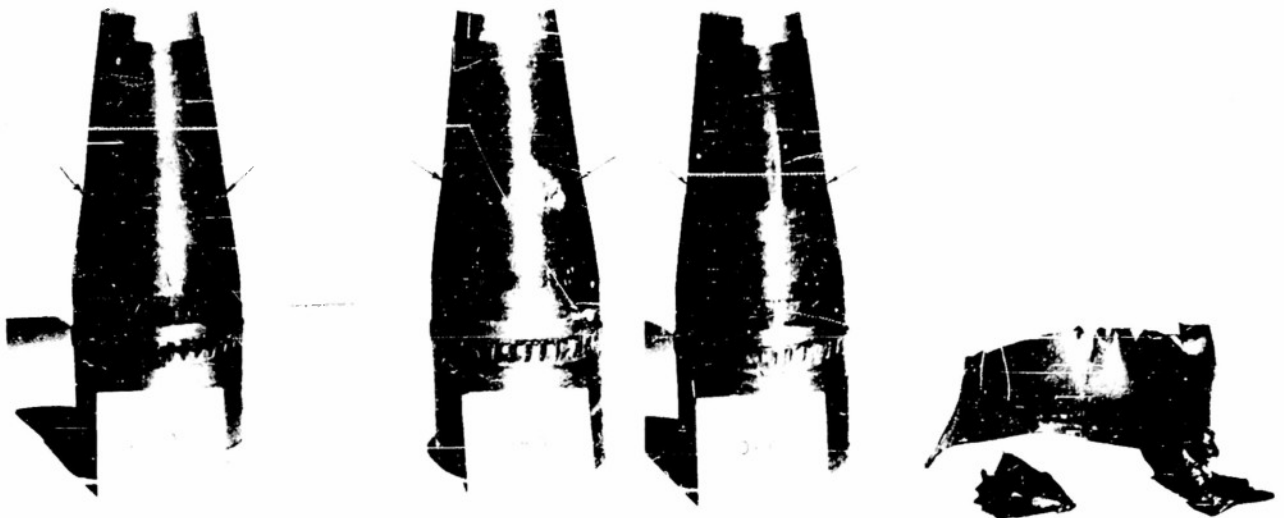


Fig. 23. Recovered Test Slugs.

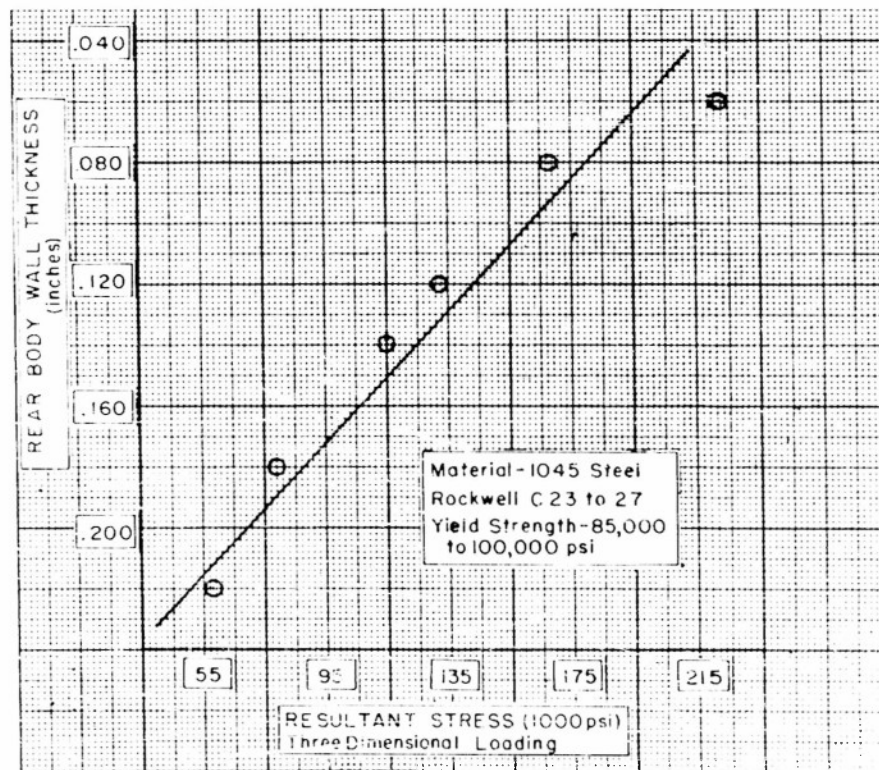


Fig. 24. Resultant Stress Versus Wall Thickness.
After Body Of Test Slug.

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Table X
Range Data
Strength Evolution Of Non-Rotated Body

Date of Test 13 February 1954

Purpose of Test Strength Evolution Of Non-Rotated Body

PROJECTILE

Model T120
Type —
Weight 2.5 lb (Standard)
CG Location —
Barrel Dia 0.78 in
Special Features Lighting Gears
Adjustable

TEST GUN

Model T14
Type 155mm Recoilless
Serial No 6
Chamber & (Line in Chamber)
Bushing Vert YAGG (Vent Open 740 in)
Tube Size 7-14
Sighting Equipment With New Telescope
Mount —
Type Fixed
Serial 234 in vs 10

MISCELLANEOUS DATA

Range Recovery Box
Propellant
Type M5-M2 With 0.90 in Weight 2.16-1.96
Lot No R40-1645
Primer 202 (2 in 1000)
Shell Case 75261
Liner DEC 479
Temperature
Magazine
Max 23°F Min 71°F Present 69°F
Loading Room 60°F Ambient 55°F

Round No	Proj No	Proj Weight (lb)	Powder Charge (lb oz)	Wind Vel & Dir	Chamber Pressure (lb 250 in)	Muzzle Velocity ft/sec	Elev (mils)	Azimuth (mils)	Position of Hit		Corrected Position (mils)	Recoil (in)	Observations
									Horiz	Vert			
6787-1	75-49	6.68	7-14		11,000	1740						2.3"	Projectile broke up in flight recovered part of projectile
6788-2	75-46	6.84	7-14		12,100	1808					(Hypox)	2.4"	Out of recovery box
6789-3	75-50	6.74	7-14		11,300	1785						16.5	Out of recovery box recovered
6790-4	75-46	6.73	7-14		11,400	1756						2.6"	Recovered
6791-5	75-45	6.76	7-14		11,400	1746						2.2"	Out of recovery box
6792-6	75-47	6.96	7-14		10,300	1766						19"	Out of recovery box recovered
AVERAGE													
						Project Weight	16.98 lb						
						Chamber Pressure	11,400 psi						
						Muzzle Velocity	1806 fps						
						Recoil	22.5 in						

Center of Impact
Instable Error—vertical
Probable Error—4 in 20 in

Project Director E. HYERMAN
Observers Sgt. Ray F. Hines

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Future Program

1. Serrated Liners

a. Effect of Index Angle

Two lots of cones of the DRD78 type, described in the Supplement to the Thirty-Fourth Progress Report, having index angles of 5° and 20° , and having minimum wall thicknesses of .100 in. are scheduled for firing in April.

b. DRD433 item 2 and item 3 cones (Index angle 6° and 2° , respectively) are being inspected. These cones have 50 "matching" flutes .034 in. deep at the base datum and a wall thickness of .100 in.

c. DRD429 item 2. These cones have 16 "matching" flutes, .034 in. deep at the base datum and a wall thickness of .100 in. Index angle is 6° . Flute orientation is the reverse of DRD78.

d. DRD434 item 2. Same as (c) except flute depth is .060 in.

e. Scaling Studies

DRD267 (3.5 in. base x .100 in. wall); DRB704 (3.0 in. base x .087 in. wall); DRB703 (2.5 in. base x .071 in. wall). These cones to have 60 flutes machined in outside to a depth of .010 in., .0085 in. and .0069 in. at base datum for each of three sizes have been manufactured and inspected.

f. Threaded Cones

DRB998, threaded inside, 60° V threads 28/in., .0097 in. deep, .0357 in. pitch.

DRB999, triple threaded inside, 60° V threads, 84/in., .0097 in. deep, .0119 in. pitch, .0357 in. lead.

DRB1000, threaded outside, 60° V threads, 28/in., .0357 in. pitch, .0097 in. deep.

DRB1001, triple threaded outside, 60° V threads, 84/in., .0357 in. lead, .0119 in. pitch, .0097 in. deep.

The above cones have been manufactured and inspected.

g. DRD393 HW1, - This cone has 50 flutes machined on the outside surface only to a depth of .0149 in. at base datum and .0051 at apex datum. Nominal wall thickness is .100 in. Cones are scheduled for firing during April.

h. DRD-16-492 - 45° angle, 50 flutes machined on the outside only to a depth of .0070 in. at the base datum and .0026 in. at the apex datum. These cones are designed for use in the T108E40 round and are to be prepared from P83580A1 cones. Cones are scheduled for testing in April.

i. Ten T119 short fin test projectiles with fin cant angles $1\frac{1}{2}$ and 2 times as great as those previously fired are being inspected and assembled for firing tests.

j. Fifteen T138 test projectiles are being inert loaded and will be fired incorporating two types of tee spacers to test their usability as a carrier for a serrated liner in future dynamic firing tests.

2. Double Body Projectile Study

a. Test double body projectiles of the DRC429-1 type for spin rate and flight behavior. The total projectile weight will be reduced possibly to as little as 17.5 lb. and the strength of the ogive will be increased.

b. Six projectiles are to be fired to complete the study of the determination of minimum wall thickness required in non-rotated body. The projectiles have wall thicknesses as follows:

C O N F I D E N T I A L

(1) 2 rounds with .180 in. wall (alum)
in rear body.

(2) 2 rounds with .120 in. wall (alum)
in rear body.

(3) 2 rounds with .060 in. wall (alum)
in rear body.

c. Determination of Strength of Tee
Or Boom. Tees of five different designs
and strength, using both aluminum and
steel, are to be tested. Manufacture is
completed and tests are scheduled for
May.

d. Evaluate efficiency of DRA218 and
DRA215 bearing system treated with #4253
Lube-Lok base coat and #4396 Lube-Lok
top coat. Rounds have been fired but
the data have not been evaluated.

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PENETRATION STUDIES

Effect Of Cone Angle and Flash Tube Diameter Upon Penetration

The systematic evaluation of the effect of cone angle and flash tube diameter upon the standoff and rotational penetration behavior of 3-inch copper cones has been completed. This work was conducted under Contract DAI-33-019-501-ORD (P)-16, Firestone Tire and Rubber Company, and the complete data are discussed in the Eleventh Progress Report under that contract. Because of the direct application of this work to the BAT project the data are summarized in Table XII and Figs. 25, 26 and 27. For detailed information

concerning these tests it is advisable to consult the referenced report.

The following two groups of cones were included in this study.

a. Central tube .628 in. O.D.; 27.5°, 30°, 35° and 42° included angle; overall height 5 in.

b. Central tube 1.000 in. O.D.; 23°, 25°, 30°, 35° and 42° included angle; overall height 5 in.

All cones were assembled in DRC506 test assemblies using No. 2 nose rings.

Table XII
Summary Of Penetration Data
Effect Of Cone Angle and Flash Tube Diameter

Cone	Apex Angle	STANDOFF (in)					ROTATION (0 rps)					ROTATIONAL BEHAVIOR (rps)					8.6 in. STANDOFF	
		4.0	8.6	12.0	16.0	24.0	0	15	30	45	90	180						
CENTRAL TUBE .628 IN.																		
DRB830	27.5°	16.86 ± .28	18.22 ± 1.40	----	16.05 ± 5.74	----	----	----	----	----	----	----	----	----	----	----	----	
DRB834	30°	17.55 ± .38	18.46 ± .73	----	18.59 ± 1.45	18.41 ± 2.72	18.46 ± .73	16.19 ± .58	----	7.10 ± 2.16	5.08 ± 1.20	3.39 ± .26	----	----	----	----	----	
DRB838	35°	16.30 ± .44	18.85 ± .38	----	18.52 ± 5.02	----	----	----	----	----	----	----	----	----	----	----	----	
DRB842	42°	16.25 ± .96	18.10 ± 1.10	----	19.55 ± .40	18.98 ± .57	18.10 ± 1.20	17.27 ± .71	----	9.65 ± 1.55	6.36 ± .53	4.72 ± .36	----	----	----	----	----	
CENTRAL TUBE 1.000 IN.																		
DRB828	23°	16.20 ± .52	17.09 ± 5.28	----	17.11 ± 2.02	----	----	----	----	----	----	----	----	----	----	----	----	
DRB832	25°	16.30 ± 1.02	19.00 ± 2.06	----	17.06 ± 2.23	----	----	----	----	----	----	----	----	----	----	----	----	
DRB836	30°	17.22 ± .47	17.71 ± 1.54	----	20.55 ± .87	----	17.71 ± 1.54	17.03 ± .97	10.69 ± 1.26	7.94 ± .81	5.48 ± 1.51	3.55 ± .22	----	----	----	----	----	
DRB840	35°	15.82 ± .92	18.28 ± 1.64	----	18.03 ± 1.17	----	----	----	----	----	----	----	----	----	----	----	----	
DRB844	42°	----	17.86 ± 1.52	18.16 ± 1.42	----	20.16 ± .93	17.86 ± 1.52	17.90 ± .72	11.28 ± 1.27	9.49 ± .89	6.60 ± .86	3.58 ± .96	----	----	----	----	----	
Note: Penetrations are reported as averages into mild steel target plate. Standard deviations are shown for each penetration value.																		

Note:
Penetrations are reported as averages into mild steel target plate. Standard deviations are shown for each penetration value.

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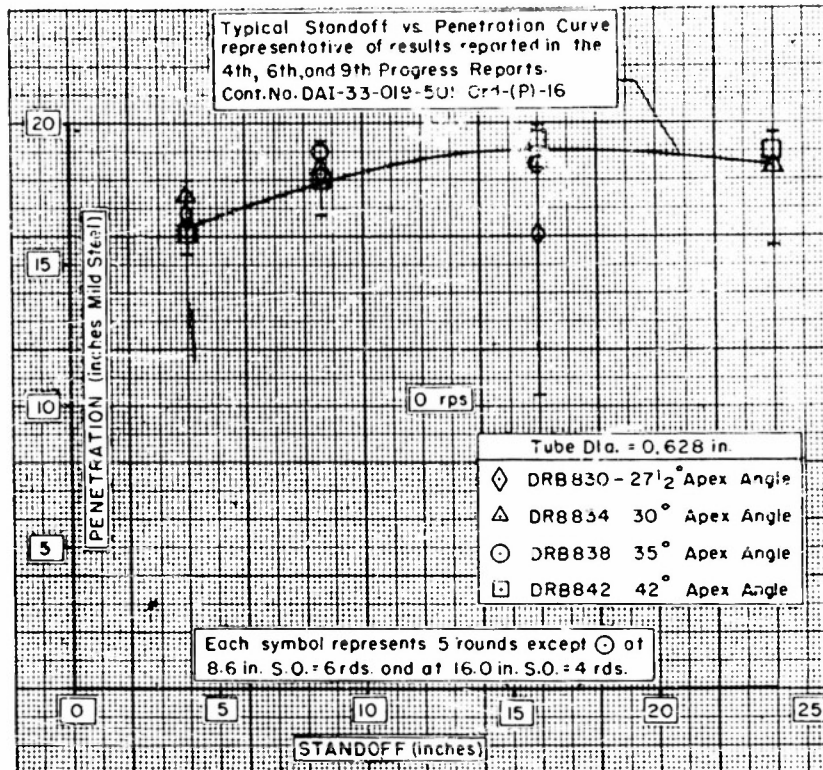


Fig. 25. Penetration Versus Standoff.
Effect Of Cone Angle

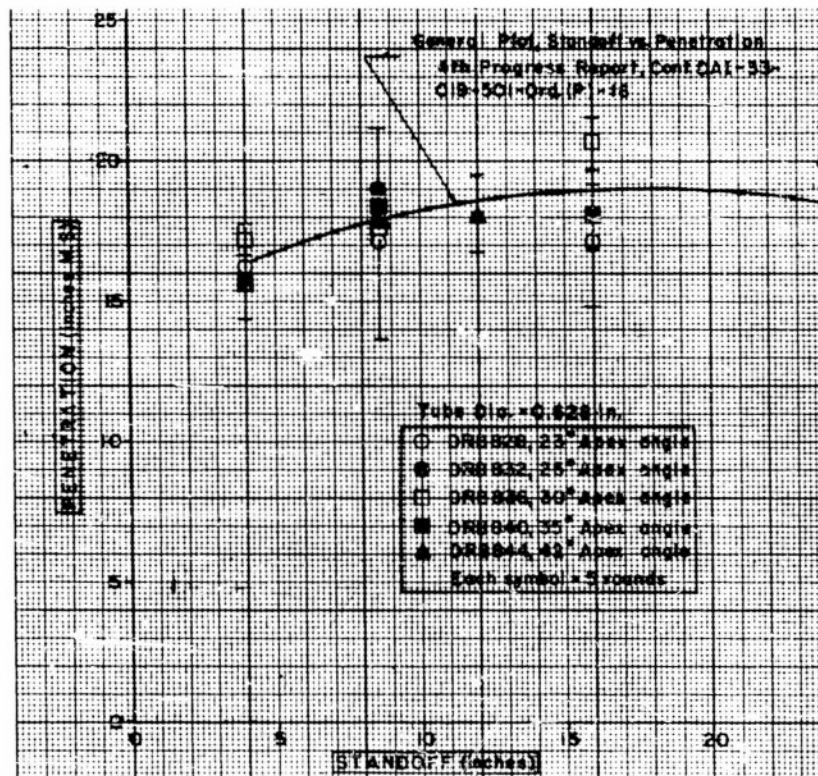


Fig. 26. Penetration Versus Standoff.
Effect Of Cone Angle.

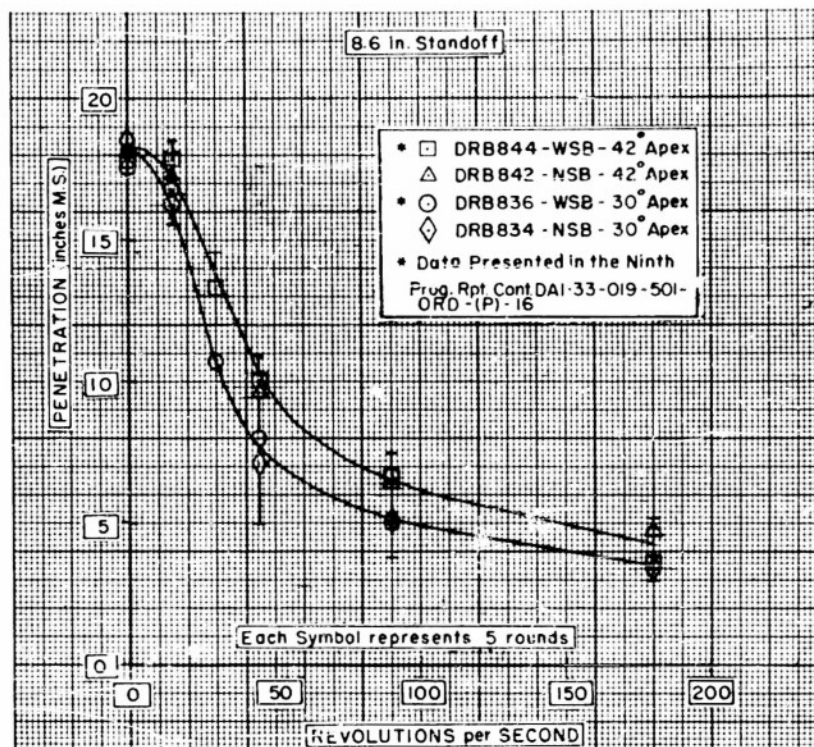


Fig. 27. Penetration Versus Rotation.
Effect Of Variations In Cone Angle and Spitback Tube Diameter.

Summary Of Study

STANDOFF BEHAVIOR

As shown in Figs. 25 and 26, there is no systematic variation in the standoff behavior with cone angle. The test data agree well with the solid curve, a typical standoff-penetration curve presented in previous reports. The reduction in the flash tube diameter from 1.000 in. O.D. size to 0.625 in. O.D. did not cause any apparent change in the standoff performance of these cones.

EFFECT OF ROTATION

Only 30° and 42° cones were tested. The penetration of the smaller angle cone falls off more rapidly with rotation as shown in Fig. 27. The spitback tube diameter has no effect. The 42° cone behavior agrees excellently with a generalized plot presented in the Thirty-Seventh Progress Report, when the longer standoff used in this study (8.6 in. vs. 6.4 in) is taken

into account.

DISCUSSION This experiment is of considerable interest since the data in certain respects are in excellent agreement with earlier work in this and other laboratories, but in other respects differs markedly from earlier work. For example, the behavior of the 42° copper cones agrees well with expected behavior and the effect of cone angle upon degradation caused by rotation agrees well with earlier experiments. But, the effect of cone angle upon both standoff behavior and penetration at fixed standoff are not in agreement with experiments with 105mm test assemblies. (See Twentieth and Twenty-Eighth Progress Reports). Also, the lack of any effect of spitback tube diameter upon penetration does not agree with data for 105mm assemblies as presented in the Twenty-Second Progress Report. There is no readily apparent reason for the lack of agreement and further tests would be required to solve the problem.

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Comparison Of The Drawn and Shear Formed P83580 A1 Cone

Two separate groups of P83580 A1 cones have been manufactured, one by shear forming, the other by deep drawing, and compared for penetration behavior. A portion of the shear formed cones were annealed to evaluate the effect of the treatment. This work was conducted under con-

tract DAI-33-019-501-ORD (P)-16 and are presented in the Eleventh Progress Report. Because the data are of importance in the BAT project the results of the study are summarized in Table XIII and Figs. 28 and 29 of this report. For detailed information concerning these tests consult the referenced report. All cones were assembled in DRC506 test assemblies using No. 2 nose rings.

Table XIII
Summary Of Penetration Data
Comparison Of The Drawn and Shear Formed P83580 A1 Cone

	6.4	STANDOFF (in)					ROTATIONAL BEHAVIOR (rpm)					STANDOFF 6.4 in			
		0.6	1.2	2.4	3.0	4.0	-30	0	15	20	45	60	90	120	180
SHEAR FORMED GROUP NO. I 5TH PROG. RPT. Cont. DAI-33-019-501-ORD (P)-16	12.52 ± .58		14.00 ± 1.17	12.80 ± 1.22	9.61 ± 1.71	6.57 ± 3.08	9.14 ± .70	12.52 ± .59	11.58 ± .04	13.73 ± 1.02	13.54 ± .71	11.06 ± .11	8.35 ± 1.11	---	5.83 ± .67
SHEAR FORMED GROUP NO. II 5TH PROG. RPT. Cont. DAI-33-019-501-ORD (P)-16	12.58 ± .48	---	13.81 ± 1.17	14.37 ± 1.40	12.42 ± 4.70	9.54 ± 1.54									
SHEAR FORMED AND ANNEALED 1 HR. AT 900°F 5TH PROG. RPT. Cont. DAI-33-019-501-ORD (P)-16	14.37 ± 1.16	---	16.96 ± .16	17.29 ± 2.52	---	---	11.52 ± 1.04	14.37 ± 1.16	13.17 ± .34	12.50 ± .16	9.98 ± .69	8.36 ± 1.42			
DEEP DRAWN 5TH PROG. RPT. 15.32 ± .96 Cont. DAI-33-019-501-ORD (P)-16	15.82 ± .46	16.95 ± .85	14.42 ± 1.43	---	---	---	15.12 ± .96	14.11 ± 1.23	12.44 ± .10	9.28 ± .13	7.95 ± .95	---	8.45 ± .52		

Note:

Penetrations are reported as averages into mild steel target plate. Standard deviations are shown for each penetration value.

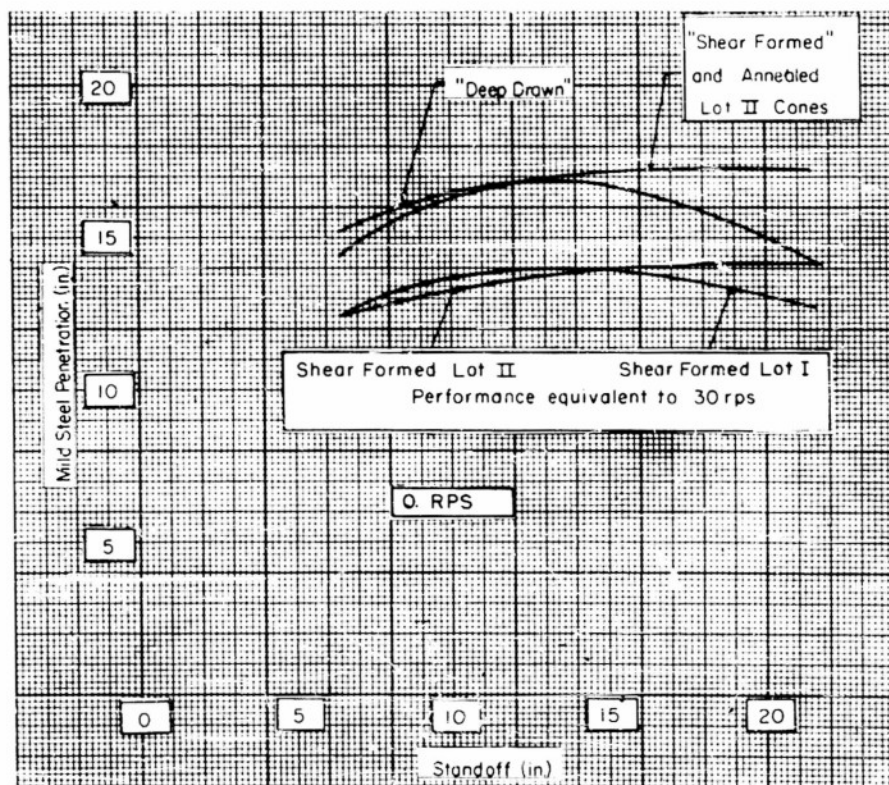


Fig. 28. Penetration Versus Standoff.
P83580 A1 Cone Study.

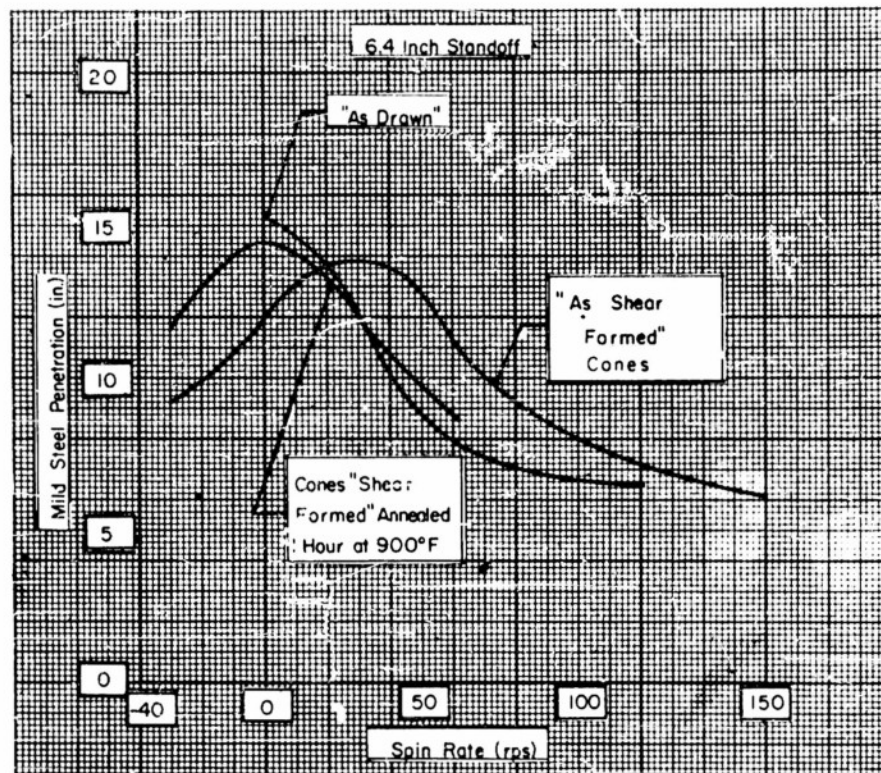


Fig. 29. Penetration Versus Rotation.
P83580 Al Cone Study.

Effect Of Standoff

It can be seen from Fig. 28 that the standoff-penetration behavior of the deep drawn cone is similar to that of the annealed shear formed cone in the lower standoff regions. At longer standoffs the performance level of the shear formed cone is maintained at a fairly constant level while the performance of the drawn cone falls off.

The relative performance of machined and drawn 3.5 inch, DRB398 copper cones

was described in the Twenty-Seventh Progress Report. It was shown that the machined cones retained their level of penetration at very long standoff distances much better than did the drawn cones. The difference was attributed to the wall waviness of the drawn cone. A similar effect is noted in comparing the P83580 Al shear formed and drawn cones.

The following tabulation is a summary of the inspection data for the drawn cones and two lots of shear formed cones.

	Drawn	Shear I	Formed II
Wall Thickness (in)			
Max	.0941	.0956	.0929
Min	.0882	.0922	.0913
Avg	.0913	.0939	.0920
Trans. Variation	.0022	.0026	.0010
Long. Variation	.0053	.0027	.0012
Wall Waviness			
Outside (in)	.0012	.0013	.0013
Inside (in)	.0057	.0034	.0027
Concentricity (T.I.R. in.)			
Base Datum	.0027	.0024	.0012
Apex Datum	.0022	.0027	.0012
Assembly	.0062	.0062	.0051

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Fig. 28 reveals that the penetration of these cones becomes poorer at long standoff in the order, Shear Formed Lot II (Best), Shear Formed Lot I (Medium), Drawn (Poorest). It is probably more than coincidence that the inspection data show the precision of manufacture of these cones to be in the same relative order. The longitudinal wall thickness variation, wall waviness and concentricity all arrange the cones in the same order of precision.

The standoff curves for all three types of cones were determined at 0 rps. As will be described in the next section of this report the shear formed cones are spin compensating and have their best penetration at 30 rps. Therefore, the standoff curve for the shear formed cones must be compared with that of a drawn cone measured at 30 rps.

Effect Of Rotation

The penetration spin rate behavior of the drawn and annealed shear formed cones is quite normal and agree well with one another. The behavior of the shear formed cones, however, was most unexpected in that they exhibit spin compensation. Instead of having a maximum penetration at 0 rps these cones penetrated best at 30 rps. At this spin rate the penetration obtained (14 inches of mild steel) is about 93% that of the non rotated drawn or annealed shear formed cones and had a

penetration equal to or greater than that of the drawn cones at all spin rates above 20 rps. The difference is nearly 4 inches at 40 rps. It is believed that the shear forming method of manufacture causes an inclined elongated grain or crystal structure which results in the spin compensating effect. Annealing of the cones completely destroys the effect. Further tests are in progress under Contract DAI-33-019-501-ORD (P)-16 and these tests show that the direction of spin compensation and the amount of the shift in optimum rotational frequency can be varied by changing the manufacturing conditions.

Double Angle Tapered Wall Cone

The performance of double angle, tapered wall thickness copper cones has received considerable attention and extensive study at Picatinny Arsenal. The excellent performance reported by Picatinny has led to an evaluation of these cones under Contract DAI-33-019-501-ORD (P)-16. The data are summarized here. Two separate groups of these cones were manufactured one by shear forming- the other by deep drawing and compared for penetration behavior. The test results are presented in the 11th Progress Report, Contract No. DAI-33-019-501-ORD-(P)-16), Firestone Tire and Rubber Co. A summary of these results is presented in Table XIV and Figs. 31 and 32. For detailed information concerning these tests it is advisable to consult the referenced report.

Table XIV
Summary Of Penetration Data
Double Angled, Tapered Wall Cones DRB-23-973

	STANDOFF (in)			ROTATIONAL BEHAVIOR (rps)							
	6.4	8.6	12.9	-30	-15	0	15	30	45	60	90
SHEAR FORMED											
11TH PROG. REP.	16.75 ± 1.75	17.54 ± 1.76	18.90 ± 1.50	5.96 ± 1.72	13.81 ± 1.65	17.54 ± 1.76	18.54 ± 1.45	18.48 ± 1.12	11.27 ± 1.13	10.29 ± 1.75	6.44 ± 1.16
Cont. DAI-33-019-501-ORD (P)-16											
DEEP DRAWN											
11TH PROG. REP.	19.08 ± 1.54	19.18 ± 2.14	14.74 ± 3.82	----	----	19.18 ± 2.14	19.06 ± 3.21	20.55 ± 1.56	18.59 ± 2.46	17.23 ± 1.90	10.12 ± 1.80
Cont. DAI-33-019-501-ORD (P)-16											
Note: Penetrations are reported as averages into mild steel target plate. Standard deviations are shown for each penetration value.											

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The Picatinny tests were made using a 3.23 in. diameter copper cone in M28 A2, 3.5 in. rockets. In this assembly the cone is brazed in and in their tests drawn and shear formed cones behaved similarly. The cones in the present tests were mounted in DRC506 test assemblies with No. 2 nose rings and are not brazed into the shell.

Fig. 30 shows both the Picatinny Cone (PX-8-929A1) and the modifications which were made (DRB-23-973).

Effect Of Rotation

The spin rate-penetration curve for the two cones is shown in Fig. 31. Like the shear formed P83580 A1 cones the DRB-23-973 shear formed cones show a spin compensating effect and have their best penetration, 20.5 inches of mild steel (6.84 effective charge diameters), at 30 rps. The drawn cones, on the other hand, show a maximum penetration of 19.3 inches (6.43 C.D.) at 0 rps. In each case the tests were conducted at a standoff of 8.6

inches (2.86 C.D.). At all spin rates above 10 rps the shear formed cones are superior to drawn cones.

Effect Of Standoff

The standoff-penetration curve is shown in Fig 32. The optimum standoff distances are 8 in. for the drawn cones and 10 in. for the shear formed cones. Since the standoff measurements were made at 0 rps the level of penetration shown by the shear formed cones is low, just as that of the drawn cones would have been had the test been conducted at 30 rps. In spite of this disadvantage in effective spin rate it appears that the shear formed cone will maintain its penetration considerably better than the drawn cone at long standoffs even though there is very little difference in the precision with which the two types of cones appear to be manufactured. It is to be expected that the shear formed cones would show to better advantage after annealing but would not have any spin compensating effect.

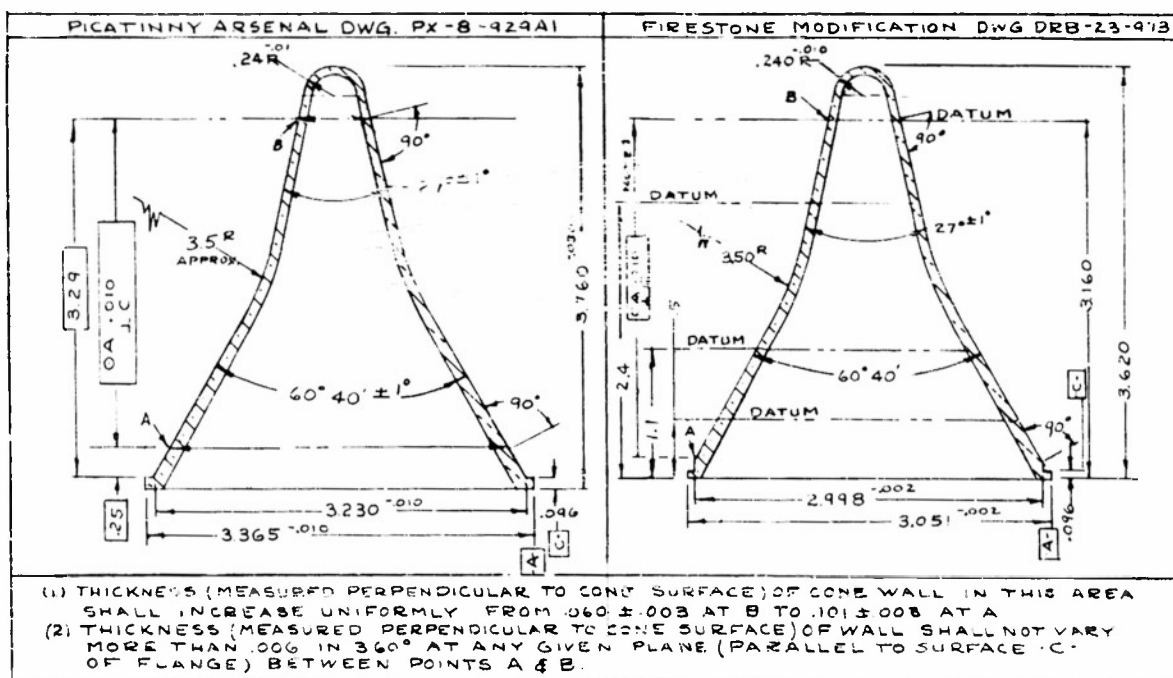


Fig. 30. Double Angle Cones.
 Picatinny Arsenal Cone PX-8-929 A1 and Firestone Modification DRB-23-973.

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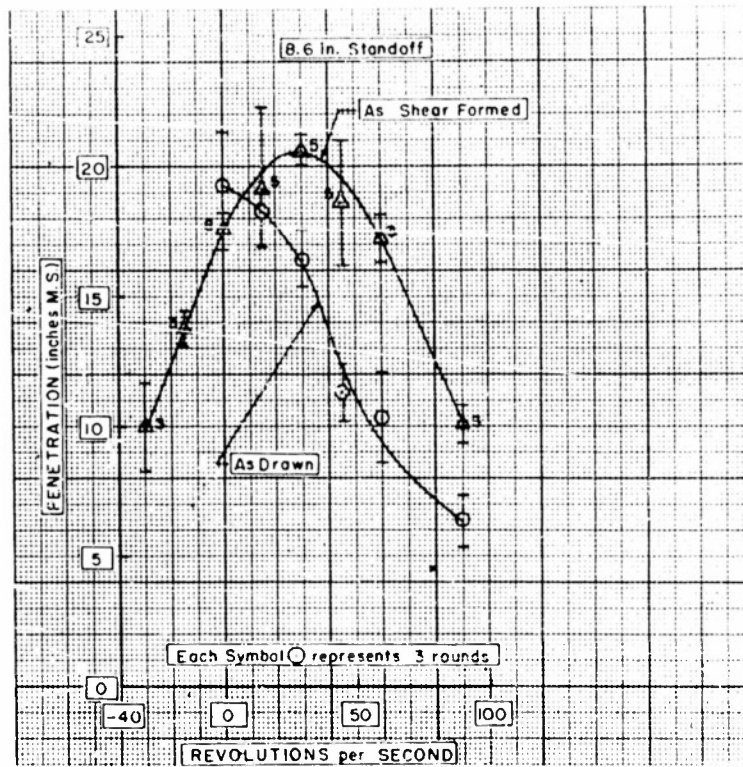


Fig. 31. Penetration Versus Rotation.
Double Angle Cones.

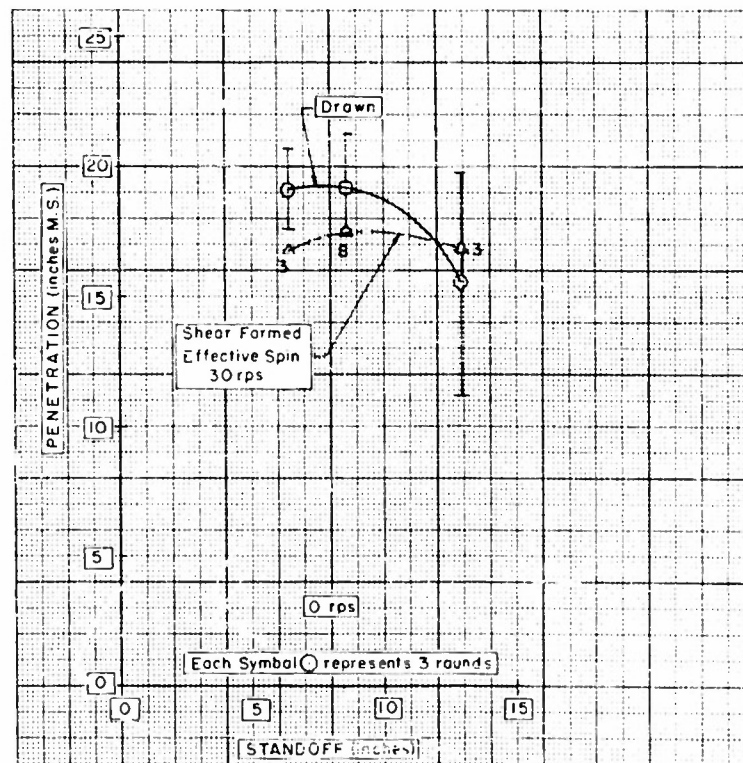


Fig. 32. Penetration Versus Standoff.
Double Angle Cones.

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Comparison With Picatinny Arsenal Data

The performance of PX-8-929A1 cones in M28 A2 static test assemblies has been determined at Picatinny Arsenal and a portion of the data are presented in the "Minutes of Shaped Charge Committee" for 6 Jan. 1954, Tables II and IV. These data are compared with the Firestone data in Figs. 33 and 34. The standoff data, Fig. 33, show good agreement between the data for Picatinny annealed shear formed cones with Firestone drawn cones. Since they were not annealed the Firestone data for

shear formed cones should not be compared with the Picatinny data.

The effect of rotation, shown in Fig. 34 is interesting. The performance of the double angle cone is not reduced with spin as rapidly as is a regular 42° or 45° conical liner. Also, the rate of loss in penetration with spin increases with stand-off. In the single instance where the stand-off distance is comparable, the Picatinny Arsenal and Firestone spin data agree quite well.

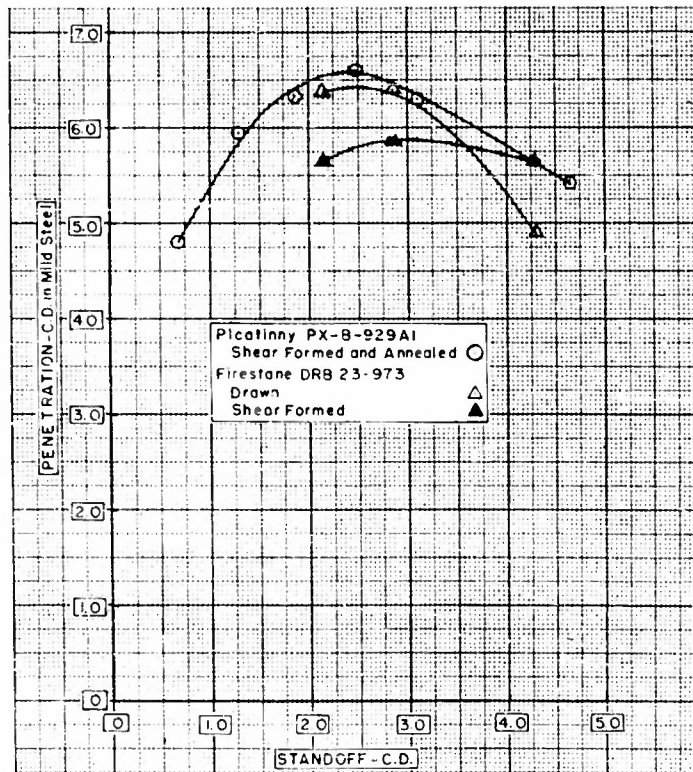


Fig. 33. Penetration Versus Standoff.
Units In Cone Diameters.

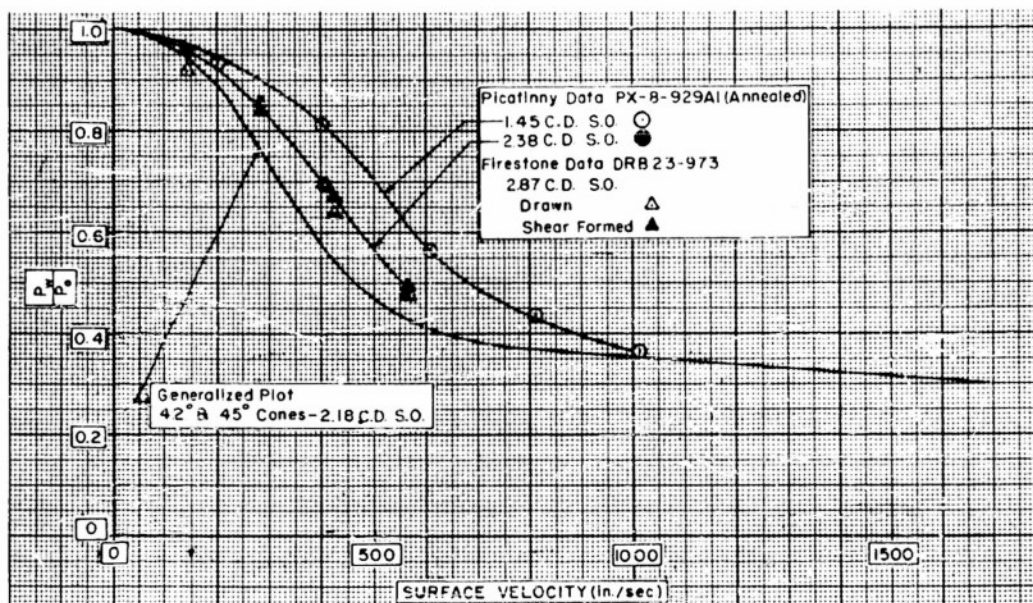


Fig. 34. Penetration Versus Surface Velocity.

Future Program

1. Composite Cone Study

A series of bimetal cones with aluminum half shell inserts (.020 in. thick) and copper outer shells (DRB398HW3 item 1) will be assembled to evaluate penetration performance at standoffs of 2, 4 and 6 in. and at varying rotational rates.

2. Evaluation of Cones Made By Electroforming

A series of DRB 268-5 copper cones, made by an electroforming method, have been manufactured for comparison with machined cones of like design. The electroformed cones are finished and the controls are being machined.

3. The Effect of Rotation on Aluminum Cone Performance

A series of DRB398HW3 item 1 and item 4 cones, machined from 2S-F aluminum bar, will be tested at various spin rates

0, 30, 45 and 60 rps at 7.5 in. standoff. A second series will be tested at the same rotational velocities but at the optimum standoff of about 42 in.

4. Penetration Into Mild Steel Versus Homogeneous Armor

A series of penetration test rounds composed of DRB398 HW3 item 1 cones in DRC-376 test bodies have been loaded and will be tested for penetration into homogeneous armor and mild steel at various spin rates.

5. Evaluation of Cones Made By Zinc Die Casting

A series of DRB398HW3 cones have been made by die casting zinc alloy Zamak 3. Standoff and spin tests are planned.

6. Evaluation of the DRB398 HW3 Item 1 Copper Drawn Cone in Various Stages of Manufacture.

A series of cones have been obtained

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having varying geometric configurations. These cones represent the various steps in the deep drawing of the DRB398 HW3 item copper cone. Six of the eight drawing stages are included. Standoff and spin tests are planned.

7. Evaluation of Optimum Wall Thickness for Cones with Various Apex Angles.

This study is being conducted using 3.0 in. charges. The length of the spitback tube (.625 in. dia.) will be varied to give the cone a over-all height of 5.00 in.

a. Cone drawing number DRB834-1, apex angle 30° , wall thickness .050 in., .070 in., .086 in. and .110 in.

b. Cone drawing number DRB16-976, apex angle 45° , wall thickness, .050 in., .110 in. and .150 in.

c. Cone drawing number DRB16-972, apex angle 60° , wall thickness, .070 in., .110 in. and .150 in.

These cones are being manufactured.

MANUFACTURING SUMMARY

In addition to the experimental material prepared for the research and development work under contracts DA-33-019-ORD-33 and DA-33-019-ORD-1202, described in preceding progress reports and in the preceding pages of this report, the following have been manufactured and shipped to the installations indicated.

Firestone's Defense Research Division, in shipping these items, transfers custody and control of the items to the receiving agencies. However, personnel of Defense Research Division will continue to collaborate with personnel of the other installations.

I. Cartridges, HEAT, 106mm, M344 (T119E11) Without Fuzes T208E7

Prior to	March 1, 1954	16,715	All Shipments
	March 24, 1954	267 (Live)	Picatinny Arsenal
	Total	16,982	

II. Rifles, T170E1 for ONTOS

Prior to	March 1, 1954	69	All Shipments
	March 27, 1954	3	Aberdeen Proving Ground
	Total	72	

III. Mounts, T173 and T26 Tripod for ONTOS

Prior to	March 1, 1954	22	All Shipments
No Shipments in March			

IV. BAT Systems less Jeep, T170E1 (M40) Rifle, T149E3 (M79) Mounts (with latest modifications).

Prior to	March 1, 1954	25	All Shipments
No Shipments in March			

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